NASA

Aeronautical Engineering
A Continuing Bibliography with Indexes

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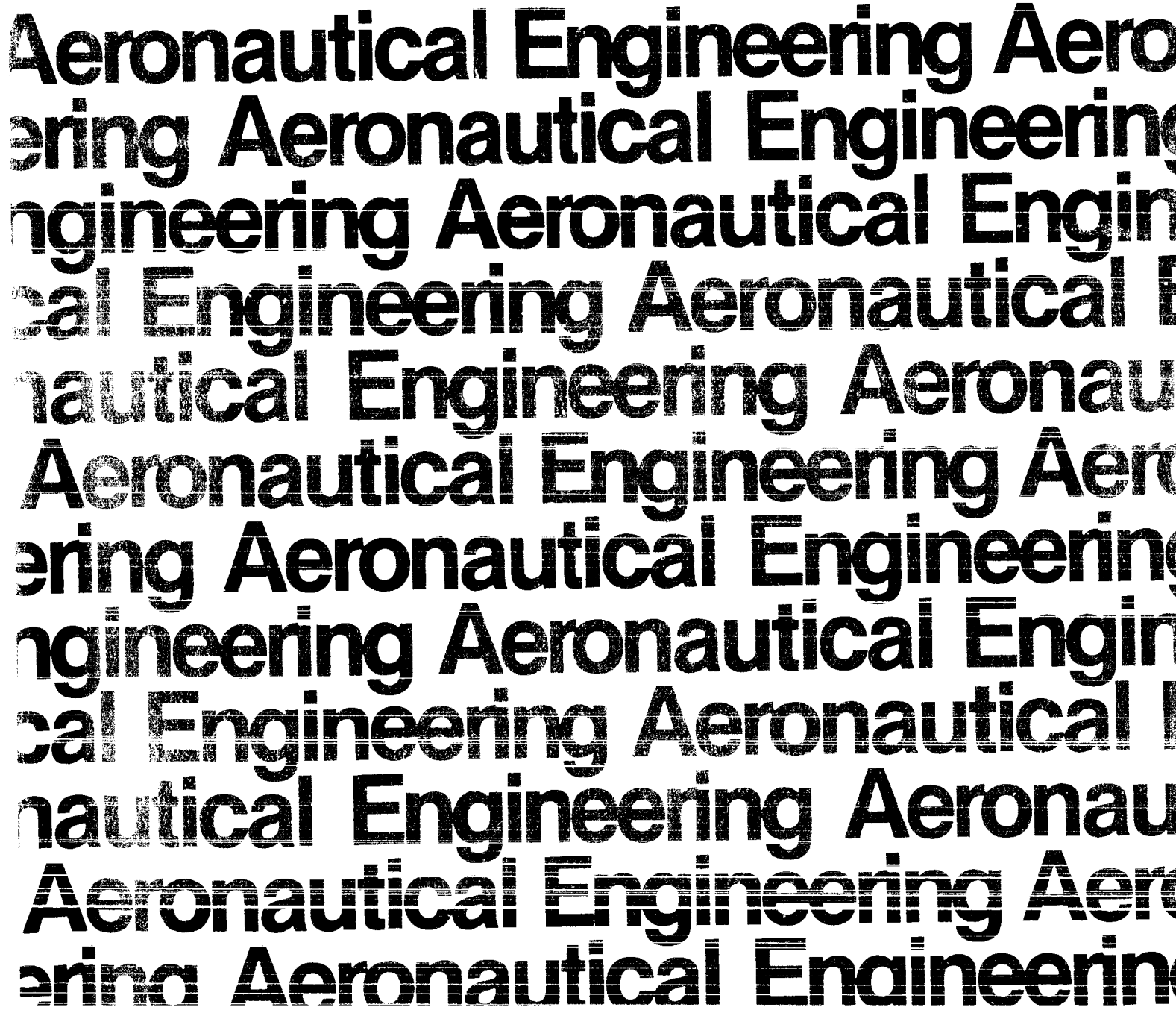
National Aeronautics and Space Administration



NASA SP-7037(206)

AERONAUTICAL ENGINEERING

A CONTINUING BIBLIOGRAPHY WITH INDEXES

(Supplement 206)

A selection of annotated references to unclassified reports and journal articles that were introduced into the NASA scientific and technical information system and announced in October 1986 in

- *Scientific and Technical Aerospace Reports (STAR)*
- *International Aerospace Abstracts (IAA).*

NASA Scientific and Technical Information Branch 1986
National Aeronautics and Space Administration
Washington, DC

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INTRODUCTION

This issue of *Aeronautical Engineering -- A Continuing Bibliography* (NASA SP-7037) lists 422 reports, journal articles and other documents originally announced in October 1986 in *Scientific and Technical Aerospace Reports (STAR)* or in *International Aerospace Abstracts (IAA).*

The coverage includes documents on the engineering and theoretical aspects of design, construction, evaluation, testing, operation, and performance of aircraft (including aircraft engines) and associated components, equipment, and systems. It also includes research and development in aerodynamics, aeronautics, and ground support equipment for aeronautical vehicles.

Each entry in the bibliography consists of a standard bibliographic citation accompanied in most cases by an abstract. The listing of the entries is arranged by the first nine *STAR* specific categories and the remaining *STAR* major categories. This arrangement offers the user the most advantageous breakdown for individual objectives. The citations include the original accession numbers from the respective announcement journals. The *IAA* items will precede the *STAR* items within each category

Seven indexes -- subject, personal author, corporate source, foreign technology, contract number, report number, and accession number -- are included.

An annual cummulative index will be published.

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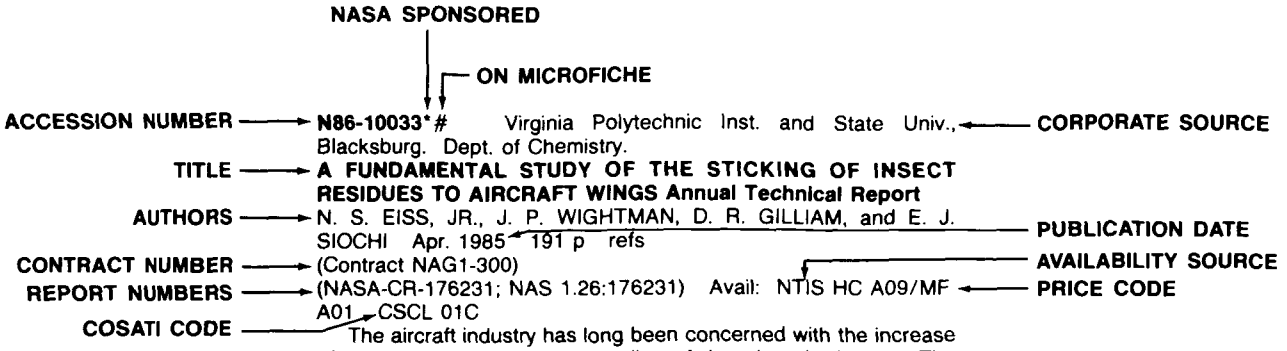
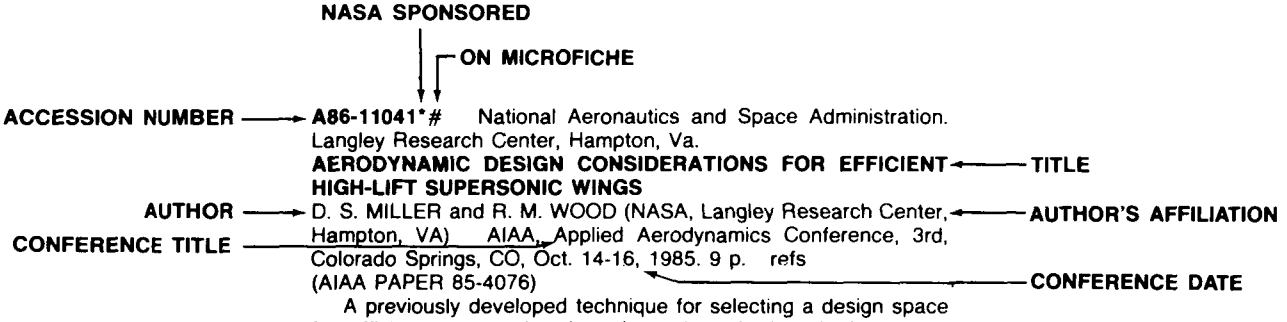
TYPICAL REPORT CITATION AND ABSTRACT



The aircraft industry has long been concerned with the increase of drag on airplanes due to fouling of the wings by insects. The present research studied the effects of surface energy and surface roughness on the phenomenon of insect sticking. Aluminum plates of different roughnesses were coated with thin films of polymers with varying surface energies. The coated plates were attached to a custom jig and mounted on top of an automobile for insect collection. Contact angle measurements, X-ray photoelectron spectroscopy and specular reflectance infrared spectroscopy were used to characterize the surface before and after the insect impact experiments. Scanning electron microscopy showed the topography of insect residues on the exposed plates. Moments were calculated in order to find a correlation between the parameters studied and the amount of bugs collected on the plates. An effect of surface energy on the sticking of insect residues was demonstrated.

Author

TYPICAL JOURNAL ARTICLE CITATION AND ABSTRACT



A previously developed technique for selecting a design space for efficient supersonic wings is reviewed; this design-space concept is expanded to include thickness and camber effects and is evaluated for cambered wings at high-lift conditions. The original design-space formulation was based on experimental upper-surface and lower-surface normal-force characteristics for flat, uncambered delta wings; it is shown that these general characteristics hold for various thickness distributions and for various amounts of leading-edge camber. The original design-space formulation was also based on the assumption that the combination of Mach number and leading-edge sweep which would produce an equal division of flat-wing lift between the upper and lower surface would also be the proper combination to give the best cambered-wing performance. Using drag-due-to-lift factor as a measure of performance, for high-lift conditions cambered-wing performance is shown to significantly increase as conditions approach the design space; this correlation is demonstrated for both subcritical and supercritical flows.

Author

AERONAUTICAL ENGINEERING

A Continuing Bibliography (Suppl. 206)

NOVEMBER 1986

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AERONAUTICS (GENERAL)

A86-40232
HEALTH AND USAGE MONITORING TECHNIQUES FOR GREATER SAFETY IN HELICOPTER OPERATIONS
D. G. ASTRIDGE International Journal of Aviation Safety (ISSN 0264-6803), vol. 3, Sept. 1985, p. 205-211. refs

Significant advancements have recently been made in helicopter gearbox monitoring technology, notably in quantitative debris monitoring (QDM) and enhanced vibration signal averaging. Attention is given to a QDM system that has demonstrated its effectiveness against a wide range of wear modes, and to vibration analysis techniques that have detected cracks and fracture modes not yet detectable by visual inspection. A comprehensive onboard monitoring system has been developed which incorporates, in addition to the two techniques mentioned, engine and rotor system monitoring elements. O.C.

A86-40478
SIMULATOR UPGRADE - REGULATIONS AND BENEFITS
E. M. BOOTHE (FAA, Atlanta, GA) IN: Simulators; Proceedings of the Conference, Norfolk, VA, March 3-8, 1985 . La Jolla, CA, Society for Computer Simulation, 1985, p. 6-12. refs

In June of 1980, the Federal Aviation Administration (FAA) Advanced Simulation Plan came into being. Since that time, there has been a significant increase in the use of Advanced Simulators in lieu of the aircraft for training and checking of pilots. It is pointed out that new advanced simulators are now coming into operation, allowing nearly 100 percent of the pilot's training and checking to be accomplished in the simulator. Attention is given to the Advanced Simulator Plan with its three phases, the National Simulation Evaluation Program, progress which has been made, regional air carriers and general aviation, and an investigation of alternatives. G.R.

A86-40499
EXPERIENCES IN UK AND FRANCE IN AEROSPACE APPLICATION
B. J. HAYES (Ciba-Geigy Plastics and Additives Co., Duxford, England) IN: Carbon fibres and their composites . Berlin and New York, Springer-Verlag, 1985, p. 229-240.

A development history is presented for British and French involvement in the design and production of high performance glass and carbon fiber-reinforced composite structures for aircraft, spacecraft, and helicopters. Propulsion-related applications of such composites have encompassed not only the familiar helicopter rotor blades and driveshaft torque-tubes, but commercial aircraft propeller blades and even CFRP fan blades (which failed due to poor impact performance). Future avenues of development in this field are projected. O.C.

A86-41037#
WHICH TRANSPORT TECHNOLOGIES WILL FLY?
J. M. SWIHART (Boeing Co., Seattle, WA) Aerospace America (ISSN 0740-722X), vol. 24, May 1986, p. 56-58.

The cost of ownership of commercial aircraft is seen as a factor that will limit which new technologies will be adopted. Today, for a 10 percent fuel saving, an airline can bear a premium of only 2.5 percent. Thus, some technologies that look promising technically will not pay off big enough to fly. Technologies that can be expected to pay off include: using computers to design improved wings; lighter materials such as aluminum-lithium alloys and composites (if labor and material costs for composite structures are not too great); computer-aided design/computer-aided manufacturing; microprocessor technology; fiber optics (to potentially reduce the heavy electromagnetic shielding required for electronics); and improved engines such as the counterrotating pusher turboprop. Fly-by-wire and fly-by-light systems, which might replace mechanical cable controlled flight systems, need to be studied further. Various of these technologies in combination may within a decade make possible a transport delivering over 150 seat-miles per gallon. Such an airliner would make most of today's aircraft obsolete - if the cost of ownership can be kept down. D.H.

A86-41276
BRINGING ON THE B-1B
J. P. COYNE Air Force Magazine (ISSN 0730-6784), vol. 69, June 1986, p. 63-69.

An account is given of the first year of B-1B bomber training operations at Dyess Air Force Base, Texas. The training schedule calls for the qualification of 250 pilots for four SAC B-1B operational wings by 1990, complemented by 300 copilots and 500 systems officers. Because the B-1B is so heavily dependent on computers and electronics, intensive avionics training is included in the Dyess program. Attention is given to such automated maintenance systems as the Central Integrated Test System and the Automated Tech Order System. O.C.

A86-41800
DELIVERY OF B-1B CHANGES MAINTENANCE PROCEDURES
Aviation Week and Space Technology (ISSN 0005-2175), vol. 124, June 2, 1986, p. 60-62.

An evaluation is made of the consequences for maintenance procedures of the B-1B bomber's incorporation of a number of revolutionary monitoring and diagnostics systems. These encompass (1) a Central Integrated Test System dedicated to maintenance diagnostics; (2) the Core Automated Maintenance System, which will substitute electronic mail for the paperwork conventionally used in maintenance; and (3) the Consolidated Aircraft Support System, which allows an aircraft to be serviced on the ramp without need for additional ground equipment to supply air cooling, water, electricity, jet fuel, and communication lines. O.C.

A86-43332#
EXPERT SYSTEMS FOR AVIATION MAINTENANCE
R. J. HUNTHAUSEN (U.S. Army, Aviation Applied Technology, Directorate, Fort Eustis, VA) AIAA and SOLE, Aerospace Maintenance Conference, 2nd, San Antonio, TX, May 21-23, 1986. 33 p.
(AIAA PAPER 86-1143)

Expert (AI-based) systems for military aircraft maintenance must furnish major advantages over all current manual and automatic diagnostics approaches, including the reduction of fault isolation downtimes, false removals, specialization requirements, and training requirments. Attention is given to a U.S. Army technology evaluation program aimed at the application of AI diagnostics to AH-64A, CH-47D, and AH-1S helicopters. Expert system architectures, maintenance and diagnostic information systems, expertise transfer systems, and future AI diagnostics trends are discussed. O.C.

N86-28049*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
A TIME-BASED CONCEPT FOR TERMINAL-AREA TRAFFIC MANAGEMENT
H. ERZBERGER and L. TOBIAS Apr. 1986 17 p Presented at the 42nd AGARD Guidance and Control Panel Symposium, Brussels, Belgium, 6-9 May, 1985
(NASA-TM-88243; NAS 1.15:88243) Avail: NTIS HC A02/MF A01 CSCL 01B

An automated air-traffic-management concept that has the potential for significantly increasing the efficiency of traffic flows in high-density terminal areas is discussed. The concept's implementation depends on the techniques for controlling the landing time of all aircraft entering the terminal area, both those that are equipped with on-board four dimensional guidance systems as well as those aircraft types that are conventionally equipped. The two major ground-based elements of the system are a scheduler which assigns conflict-free landing times and a profile descent advisor. Landing times provided by the scheduler are uplinked to equipped aircraft and translated into the appropriate four dimensional trajectory by the on-board flight-management system. The controller issues descent advisories to unequipped aircraft to help them achieve the assigned landing times. Air traffic control simulations have established that the concept provides an efficient method for controlling various mixes of four dimensional-equipped and unequipped, as well as low-and high-performance, aircraft. Author

N86-28050*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
GEOMETRY DEFINITION AND GRID GENERATION FOR A COMPLETE FIGHTER AIRCRAFT
T. A. EDWARDS Apr. 1986 15 p Presented at the AGARD Symposium on Applications of CED in Aeronautics, Aix en Provence, France, 7-10 Apr. 1986
(NASA-TM-88242; A-86208; NAS 1.15:88242) Avail: NTIS HC A02/MF A01 CSCL 01B

Recent advances in computing power and numerical solution procedures have enabled computational fluid dynamicists to attempt increasingly difficult problems. In particular, efforts are focusing on computations of complex three-dimensional flow fields about realistic aerodynamic bodies. To perform such computations, a very accurate and detailed description of the surface geometry must be provided, and a three-dimensional grid must be generated in the space around the body. The geometry must be supplied in a format compatible with the grid generation requirements, and must be verified to be free of inconsistencies. This paper presents a procedure for performing the geometry definition of a fighter aircraft that makes use of a commercial computer-aided design/computer-aided manufacturing system. Furthermore, visual representations of the geometry are generated using a computer graphics system for verification of the body definition. Finally, the three-dimensional grids for fighter-like aircraft are generated by means of an efficient new parabolic grid generation method. This method exhibits good control of grid quality. Author

N86-28051*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
DEVELOPMENT AND VALIDATION OF THE CREW-STATION SYSTEM-INTEGRATION RESEARCH FACILITY
B. NEDELL, G. HARDY, T. LICHTENSTEIN, G. LEONG, and D. THOMPSON May 1986 24 p
(NASA-TM-86841; A-85410; NAS 1.15:86841) Avail: NTIS HC A02/MF A01 CSCL 01B

The various issues associated with the use of integrated flight management systems in aircraft were discussed. To address these issues a fixed base integrated flight research (IFR) simulation of a helicopter was developed to support experiments that contribute to the understanding of design criteria for rotorcraft cockpits incorporating advanced integrated flight management systems. A validation experiment was conducted that demonstrates the main features of the facility and the capability to conduct crew/system integration research. Author

N86-28906# Perkin-Elmer Corp., Pomona, Calif. Applied Science Div.
DEVELOPMENT OF A PORTABLE WEAR METAL ANALYZER FOR FIELD USE Final Report, Aug. 1982 - Aug. 1985
W. NIU Aug. 1985 115 p
(Contract F33615-81-C-2080)
(AD-A166013; AFWAL-TR-85-2043) Avail: NTIS HC A06/MF A01 CSCL 07D

The portable wear metal analyzer (PWMA) was developed to perform engine oil analysis when aircraft are deployed away from their home bases. The analyzer can detect nine wear metals in the parts per million concentration ranges. The analyzer uses the graphite furnace atomic absorption technology with a specially developed multi-element analysis scheme. The overall system is packaged into two militarized suitcases, including a nine-channel spectrometer, an air or water-cooled graphite furnace, a miniaturized graphite furnace power supply, a unique sample introduction device, a pneumatic supply system, and microprocessor controlled electronics. The analyzer is simple to set up and use. The operator only needs to introduce an undiluted oil sample, push a start button and wait for the results to be printed out. A brassboard system was first developed followed by six prototypes. Analytical performance as well as environmental compatibility were thoroughly evaluated on the first prototype. Consequently, design improvements were made and incorporated into five subsequent prototypes. Test results of the prototypes indicated that the instruments can meet the oil analysis need in both laboratory and rugged environments. Field tests are under way and the results will further verify the validity of the instruments. GRA

N86-28907# Office National d'Etudes et de Recherches Aerospatiales, Paris (France).
ACTIVITIES REPORT IN AEROSPACE RESEARCH Annual Report, 1984
24 Apr. 1985 195 p
(ESA-86-97190) Avail: NTIS HC A09/MF A01

Research in aerodynamics; test facilities; spacecraft and aircraft construction materials; spacecraft and aircraft structures; computer science; fluid mechanics; energetics; physics; and aerospace systems is summarized. ESA

N86-28908# Joint Publications Research Service, Arlington, Va.
USSR REPORT: TRANSPORTATION
1 May 1986 61 p Transl. into ENGLISH from various Russian articles
(JPRS-UTR-86-007) Avail: NTIS HC A04/MF A01

General articles from various periodicals are reprinted on transportation in the USSR. Transportation areas are divided generally into civil aviation, motor vehicles and highways, marine and river fleets, and experimental systems. The majority of the articles are on civil aviation.

N86-28909# Joint Publications Research Service, Arlington, Va.
AEROFLOT OFFICIALS ROUNDTABLE ON SECTION'S TECHNICAL PROGRESS
S. SOKOLOV and I. KAZANSKIY *In its* USSR Report: Transportation (JPRS-UTR-86-007) p 1-9 1 May 1986 Transl. into ENGLISH from Grazhdanskaya Aviatsiya (Moscow, USSR), no. 2, Feb. 1986 p 30-33
Avail: NTIS HC A04/MF A01

A roundtable discussion is presented on the resolution of the key task of the 12th five-year plan which is the utmost acceleration of scientific and technical progress and an increase in the role of science and technology in transferring the industry onto the rails of the all around intensification and raising to the efficiency and quality of air transportation. A list and affiliation of the participant in the discussion is given. A verbatim script of the discussion is given. E.R.

N86-28910# Joint Publications Research Service, Arlington, Va.
GENERAL DESIGNER BALABUYEV ON AN-124 RUSLAN FEATURES
P. V. BALABUYEV and V. I. TOLMACHEV *In its* USSR Report: Transportation (JPRS-UTR-86-007) p 14-21 1 May 1986 Transl. into ENGLISH from Tekhnika-Molodezhi (Moscow, USSR), no. 2, Feb. 1986 p 30-35
Avail: NTIS HC A04/MF A01

An interview is presented with the designers of a new cargo aircraft. They state that the appearance of the An-22 (Antey) winged heavyweight, capable of carrying 80 tons of different cargo, became a sensation 20 years ago. Created on the same drawing board as the Antey, the Ruslan has a cargo capacity which is almost double that of its older brother 5. It has already scored 21 world records, including carrying a load of 171.2 tons to an altitude of 10,700 meters. The designers are further questioned about the basic features, advantages, weight reduction, engine type, maintenance, and flight safety. E.R.

02

AERODYNAMICS

Includes aerodynamics of bodies, combinations, wings, rotors, and control surfaces; and internal flow in ducts and turbomachinery.

A86-40107#
AIRFOIL OPTIMIZATION
P. KRANTZ and S. G. HEDMAN (Flygtekniska Forsoksanstalten, Bromma, Sweden) (International Council of the Aeronautical Sciences, Congress, 14th, Toulouse, France, September 9-14, 1984, Proceedings. Volume 2, p. 861-867) Journal of Aircraft (ISSN 0021-8669), vol. 23, May 1986, p. 355, 356. Previously cited in issue 22, p. 3173, Accession no. A84-45023.

A86-40108#
GROUND EFFECT ON SLENDER WINGS AT MODERATE AND HIGH ANGLES OF ATTACK
J. ER-EL and D. WEIHS (Technion - Israel Institute of Technology, Haifa) (International Council of the Aeronautical Sciences, Congress, 14th, Toulouse, France, September 9-14, 1984, Proceedings. Volume 2, p. 896-904) Journal of Aircraft (ISSN 0021-8669), vol. 23, May 1986, p. 357, 358. Previously cited in issue 22, p. 3174, Accession no. A84-45026.

A86-40110*# General Dynamics Corp., Fort Worth, Tex.
VISCOUS EFFECTS ON TRANSONIC AIRFOIL STABILITY AND RESPONSE
H. M. BERRY (General Dynamics Corp., Fort Worth, TX), J. T. BATINA (NASA, Langley Research Center, Hampton, VA), and T. Y. YANG (Purdue University, West Lafayette, IN) (Structures, Structural Dynamics, and Materials Conference, 26th, Orlando, FL, April 15-17, 1985, Technical Papers. Part 2, p. 10-22) Journal of Aircraft (ISSN 0021-8669), vol. 23, May 1986, p. 361-369. Previously cited in issue 13, p. 1845, Accession no. A85-30321. refs
(Contract NAG1-372)

A86-40111#
INDICIAL COEFFICIENTS FOR A CROPPED DELTA WING IN INCOMPRESSIBLE FLOW
V. J. E. STARK (Saab Scania AB, Linkoping, Sweden) Journal of Aircraft (ISSN 0021-8669), vol. 23, May 1986, p. 370-375. Research supported by the Swedish Defence Administration and Saab Scania AB. refs

Indicial coefficients and corresponding deficiency functions have been calculated for typical deflection modes of a cropped delta wing with trailing-edge flaps in incompressible flow by an approximate doublet element method for arbitrary motion. The normalized deficiency functions for the modes considered were found to be closely approximated by a single one-parameter function. The parameter, a characteristic time, was found to have the same value for this wing as for a rectangular wing of aspect ratio 3 when referred to semispan divided by freestream speed. Laplace transformation of the one-parameter function yields a generalized Theodorsen function. Author

A86-40112#
EULER SOLUTIONS FOR AIRFOIL/JET/GROUND-INTERACTION FLOWFIELDS
R. K. AGARWAL and J. E. DEESE (McDonnell Douglas Research Laboratories, St. Louis, MO) Journal of Aircraft (ISSN 0021-8669), vol. 23, May 1986, p. 376-381. refs

Airfoil/jet/ground-interaction flowfields are calculated by solving Euler equations on body-conforming curvilinear grids. For these computations, Jameson's Euler code (FLO-53) based on an explicit Runge-Kutta time-marching finite-volume procedure is modified. Euler equations are preconditioned for computing almost incompressible flows. Euler equations capture the vortex formation behind the jet and most of the airfoil/jet/ground-plane interaction, except the effect of entrainment. Reasonable agreement is obtained between the calculated and experimental values of the lift on the airfoil for moderate values of jet-velocity to freestream-velocity ratio. Author

A86-40115#
AERODYNAMIC INVESTIGATIONS TOWARD AN ADAPTIVE AIRFOIL FOR A TRANSONIC TRANSPORT AIRCRAFT
G. REDEKER, G. WICHMANN (DFVLR, Brunswick, West Germany), and H.-C. OELKER (Braunschweig, Technische Universitaet, Brunswick, West Germany) (International Council of the Aeronautical Sciences, Congress, 14th, Toulouse, France, September 9-14, 1984, Proceedings. Volume 2, p. 868-880) Journal of Aircraft (ISSN 0021-8669), vol. 23, May 1986, p. 398-405. Previously cited in issue 22, p. 3173, Accession no. A84-45024. refs

A86-40118*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
UNSTEADY TRANSONIC FLOW CALCULATIONS FOR INTERFERING LIFTING SURFACE CONFIGURATIONS
J. T. BATINA (NASA, Langley Research Center, Hampton, VA) Journal of Aircraft (ISSN 0021-8669), vol. 23, May 1986, p. 422-430. Previously cited in issue 19, p. 2742, Accession no. A85-40783. refs

A86-40121#
DUAL-WING SYSTEMS WITH DECALAGE ANGLE OPTIMIZATION
K. ROKHSAZ and B. P. SELBERG (Missouri-Rolla, University, Rolla) Journal of Aircraft (ISSN 0021-8669), vol. 23, May 1986, p. 444-448. Previously cited in issue 20, p. 2850, Accession no. A84-41335. refs

A86-41690#
APPLICATION OF CONTINUOUS VORTICITY PANELS TO GENERAL UNSTEADY INCOMPRESSIBLE TWO-DIMENSIONAL LIFTING FLOWS
M. J. KIM and D. T. MOOK (Virginia Polytechnic Institute and State University, Blacksburg) Journal of Aircraft (ISSN 0021-8669), vol. 23, June 1986, p. 464-471. Previously cited in issue 07, p. 842, Accession no. A85-19633. refs

A86-41693*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
WAKE HAZARD ALLEVIATION ASSOCIATED WITH ROLL OSCILLATIONS OF WAKE-GENERATING AIRCRAFT
V. J. ROSSOW (NASA, Ames Research Center, Moffett Field, CA) Journal of Aircraft (ISSN 0021-8669), vol. 23, June 1986, p. 484-491. Previously cited in issue 21, p. 3039, Accession no. A85-43835. refs

A86-41697*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
APPLICATION OF A SUPERSONIC EULER CODE (SWINT) TO WING-BODY-TAIL GEOMETRIES
J. M. ALLEN and J. C. TOWNSEND (NASA, Langley Research Center, Hampton, VA) Journal of Aircraft (ISSN 0021-8669), vol. 23, June 1986, p. 513-519. Previously cited in issue 21, p. 3040, Accession no. A85-43859. refs

A86-41734*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
MEASURED AND PREDICTED HEATING DISTRIBUTIONS FOR BICONICS AT MACH 10
C. G. MILLER, P. A. GNOFFO, and S. E. WILDER (NASA, Langley Research Center, Hampton, VA) Journal of Spacecraft and Rockets (ISSN 0022-4650), vol. 23, May-June 1986, p. 251-258. refs

Laminar heating distributions have been measured on a 1.9 percent scale model of a generic aeroassisted vehicle taking the shape of a spherically blunted, 13-deg/7-deg biconic whose forecone section is bent upward (by 7 deg) to furnish self-trim capability at a 20-deg angle-of-attack. The results thus obtained were compared with data gathered for a straight biconic. While no Reynolds number effect on heating was noted on the windward side of the forecone, the opposite was true of the leeward side, where a Reynolds number increase caused circumferential flow separation at lower angles of attack. Generally, windward heating was predicted to within 10 percent with a computer code solving the steady, three-dimensional parabolized Navier-Stokes equations. O.C.

A86-42168
EXPERIMENTAL INVESTIGATION OF THE TURBULENT BOUNDARY LAYER AT HIGH REYNOLDS NUMBERS AND A MACH NUMBER OF 0.8
L. GAUDET (Royal Aircraft Establishment, Bedford, England) Aeronautical Journal (ISSN 0001-9240), vol. 90, March 1986, p. 83-94. refs

Measurements of the turbulent boundary layer on a sidewall of the RAE 8 ft x 8 ft wind tunnel are described. Velocity profiles and wall shear-stress measurements were obtained for a Mach number of 0.8 over a Reynolds number range of over a decade up to a value of nearly 400 million. A skin-friction relationship is deduced together with a description of the velocity profile and boundary-layer growth based upon the velocity-defect law using kinematic parameters for constant-pressure flows without heat transfer. Previous data for Mach numbers up to 2.8 obtained in the same tunnel are shown to be well matched with the present analysis and the use of simple scaling factors for compressible flows is confirmed. Author

A86-42548
NUMERICAL STUDY OF THE TRAILING EDGE REGION IN SLIP FLOW REGIME
L. GOTTESDIENER (Paris VI, Universite, Meudon, France) IN: Rarefied gas dynamics. Volume 1 . New York, Plenum Press, 1985, p. 523-533. refs

The supersonic rarefied flow over a finite flat plate has been computed using a finite-difference solution of the complete unsteady Navier-Stokes equations. The solution is advanced in time from the initial conditions until the steady state solution is reached. The computational region extends from the free stream ahead of the plate to the near wake. Both wall slip and temperature jump are included in the calculations. The results compare favorably with experimental data, but some deviations are noted in the trailing edge region. Particularly the local shear stress coefficient increases approaching the trailing edge. This result gives reinforcement of the Triple Deck Theory. Author

A86-42605#
COMPUTATION OF TWO-DIMENSIONAL TRANSONIC CASCADE FLOW USING A NEW NAVIER-STOKES SOLVER
N. SATOFUKA, K. MORINISHI (Kyoto Institute of Technology, Japan), T. TAMAKI, and A. SHIMIZU (Ishikawajima-Harima Heavy Industries Co., Ltd., Tokyo, Japan) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 22nd, Huntsville, AL, June 16-18, 1986. 11 p. refs
(AIAA PAPER 86-1381)

A new explicit method for calculating viscous flows in turbomachinery cascades has been developed. The thin-layer Navier-Stokes equations are solved by using the rational Runge-Kutta time stepping procedure of Wambecq (1978) combined with the usual central finite difference approximations. The Baldwin-Lomax (1978) eddy-viscosity model is used for turbulent flows. Convergence to a steady state is accelerated by use of the local time stepping and the residual averaging techniques. Details of the numerical method are presented along with computed result for two transonic cascades. Results are compared with experimental data to demonstrate the accuracy and computational efficiency of the present method. Author

A86-42635*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
STUDY OF HYPERSONIC INLET FLOW FIELDS WITH A THREE-DIMENSIONAL NAVIER-STOKES CODE
A. KUMAR and G. Y. ANDERSON (NASA, Langley Research Center, Hampton, VA) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 22nd, Huntsville, AL, June 16-18, 1986. 11 p. refs
(AIAA PAPER 86-1426)

A three-dimensional Navier-Stokes code is used to study the flow through an inlet with a rectangular capture area, but with circular or essentially circular internal cross-sections. The inlet may have a center body extending partially or fully over the length of the inlet. Calculations are made under a variety of geometrical constraints imposed on the inlet cross-sections to study the flow quality in the inlet. It is observed that for this class of inlets, the boundary layer has a tendency to thicken and separate readily due to the adverse pressure gradient caused by the continuous compression in the inlet. Since no experimental results are yet available, this paper has presented only the numerical results from the present analysis. Author

A86-42653#
WAKE INDUCED UNSTEADY AERODYNAMIC INTERACTIONS IN A MULTI-STAGE COMPRESSOR
V. R. CAPACE and S. FLEETER (Purdue University, West Lafayette, IN) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 22nd, Huntsville, AL, June 16-18, 1986. 10 p. USAF-supported research. refs
(AIAA PAPER 86-1455)

The effects of steady loading and the detailed aerodynamic forcing function on airfoil row unsteady aerodynamics are investigated and quantified at high reduced frequency values. For the first time, both parallel and normal gust components of the forcing function are considered. This is accomplished by a series of experiments which quantify the unsteady aerodynamics of the first stage vane row of a research compressor. The effects of steady vane aerodynamic loading with both non-constant and constant aerodynamic forcing functions are quantified. These data show that the steady loading affects only the magnitude of the complex dynamic pressure coefficient whereas the ratios of the maximum amplitudes of the parallel and normal components of the aerodynamic forcing function affects both the magnitude and the phase lag. The relative effects of the two components of the time-variant inlet velocity field on the resulting vane row unsteady aerodynamics are also investigated, showing that the parallel component of the aerodynamic forcing function affects only the dynamic pressure coefficient phase lag. The correlation of the dynamic pressure coefficient data with flat plate predictions is also considered. The level and chordwise distribution of the steady aerodynamic loading, not the incidence angle, are revealed to be the key parameters to obtain good correlation with such mathematical models. Author

A86-42654#
EFFECTS OF S-BENDS ON DIFFUSER INTERNAL PERFORMANCE AND TURBULENCE CHARACTERISTICS
W. H. BALL and A. F. CAMPBELL (Boeing Military Airplane Co., Seattle, WA) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 22nd, Huntsville, AL, June 16-18, 1986. 11 p. refs
(AIAA PAPER 86-1459)

This paper presents the results from an experimental program that was conducted to investigate the effects of S-bends on diffuser internal flow behavior. The investigation was conducted using a unique test apparatus that simulates the diffuser entrance conditions behind a M sub 0 = 2.5 supersonic inlet. Results are presented from the theoretical analysis used to design the model and the experimental data obtained during the test program. The results from the program show that, although there are localized regions of separated flow present in the S-bend diffuser, the resulting effects on engine face recovery, turbulence, and distortion are small. Author

A86-42655#
S-DUCT INLET/DIFFUSERS FOR TURBOPROP OFFSET GEARBOX APPLICATIONS
P. L. MCDILL (Boeing Commercial Airplane Co., Seattle, WA) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 22nd, Huntsville, AL, June 16-18, 1986. 7 p.
(AIAA PAPER 86-1462)

A test program, utilizing a large-scale model, was run in the NASA/Lewis Research Center 10 by 10-ft wind tunnel to examine the influence on performance of design parameters of turboprop S-duct inlet/diffuser systems. The parametric test program investigated inlet lip thickness, inlet/diffuser cross-sectional geometry, throat design Mach number, and shaft fairing shape. The test program was run at angles of attack to 15 deg and tunnel Mach numbers to 0.35. Results of the program indicate that current design techniques can be used to design inlet/diffuser systems with acceptable total pressure recovery, but several of the design parameters, notably lip thickness (contraction ratio) and shaft fairing cross section, must be optimized to prevent excessive distortion at the compressor face. Author

A86-42686#
CALCULATION OF ANNULAR NOZZLE TRISONIC FLOWFIELDS BY THE METHOD OF CHARACTERISTICS
B. N. WANG and J. D. HOFFMAN (Purdue University, West Lafayette, IN) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 22nd, Huntsville, AL, June 16-18, 1986. 17 p. refs
(AIAA PAPER 86-1519)

A numerical algorithm based on the unsteady two-dimensional method of characteristics is presented for calculating axisymmetric inviscid trisonic flowfields in annular nozzles. The algorithm is an explicit second-order accurate predictor-corrector procedure. An inverse marching method based on a local network of wavelines and the pathline is employed, wherein the solution grid in physical space is prespecified. An orthogonal uniform transformed space, obtained by an algebraic grid generation method, is used for flow property interpolation in the initial-data surface. Steady flow solutions are obtained as the asymptotic solution in time. Results are presented for four annular nozzles. Comparison of the predicted and measured wall pressure distributions and nozzle efficiencies show good agreement. Author

A86-42687*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
AN LU IMPLICIT SCHEME FOR HIGH SPEED INLET ANALYSIS
S. YOON (NASA, Lewis Research Center; Sverdrup Technology, Inc., Cleveland, OH) and A. JAMESON (Princeton University, NJ) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 22nd, Huntsville, AL, June 16-18, 1986. 7 p. refs
(AIAA PAPER 86-1520)

A numerical method is developed to analyze the inviscid flowfield of a high speed inlet by the solution of the Euler equations. The LU implicit scheme in conjunction with adaptive dissipation proves to be an efficient and robust nonoscillatory shock capturing technique for high Mach number flows as well as for transonic flows. Author

A86-42688*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
IMPROVED EULER ANALYSIS OF ADVANCED TURBOPROP PROPELLER FLOWS
O. YAMAMOTO, J. M. BARTON (Sverdrup Technology, Inc., Middleburg Heights, OH), and L. J. BOBER (NASA, Lewis Research Center, Cleveland, OH) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 22nd, Huntsville, AL, June 16-18, 1986. 10 p. refs
(Contract NAS3-24105)
(AIAA PAPER 86-1521)

An implicit approximate factorization scheme in conjunction with a new boundary treatment was used to compute the inviscid flow field about an advanced high-speed propeller. The method of characteristics was used to apply impermeable boundary conditions. The convergence history of numerical calculations shows substantial decrease in the residual error decay. Euler solutions were computed for SR-3 propeller geometry and the results were compared with the experimental data and previous numerical results. Author

A86-42689#
VSAERO ANALYSIS OF A WING/PYLON/NACELLE CONFIGURATION
W. K. LORD and S. H. ZYSMAN (United Technologies Corp., Pratt and Whitney, East Hartford, CT) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 22nd, Huntsville, AL, June 16-18, 1986. 9 p. refs
(AIAA PAPER 86-1523)

The VSAERO panel code was used to simulate the flow about a wing/pylon/nacelle configuration for which detailed experimental data were available. Good agreement between analytical and experimental pressure distributions was obtained at subsonic conditions, including prediction of relatively subtle interference effects. It was found that the accuracy of the flow solution can be adversely affected by improper panelling. Interference effects

at transonic conditions were not accurately represented by the VSAERO solution, as would be expected based on the linearized-potential formulation. Author

A86-42700#
NUMERICAL NAVIER-STOKES SOLUTIONS OF HIGH SPEED PROPELLER FLOWS
S. J. YOON and J. A. SCHETZ (Virginia Polytechnic Institute and State University, Blacksburg) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 22nd, Huntsville, AL, June 16-18, 1986. 10 p. Research supported by the Virginia Center for Coal and Energy Research. refs
(AIAA PAPER 86-1538)

A numerical procedure based on the full, Reynolds averaged Navier-Stokes equations as applied to the flow near a propeller is developed. The flow is assuemd axi-symmetric, and the unsteady equations of motion are solved by MacCormack's explicit scheme. The propeller is modeled as an actuator disk, and turbulent transport is modeled by a mixing length model with a simple extension to include the effects of swirl. Computed flowfield results for the NASA/Hamilton Standrd SR1 and SR3 advanced turboprop (propfan) are compared with wind tunnel data. Good agreement was achieved with the present method. Author

A86-42706#
THEORETICAL AND EXPERIMENTAL ANALYSIS OF HIGHSPEED PROPELLER AERODYNAMICS
J. M. BOUSQUET (ONERA, Chatillon-sous-Bagneux, France) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 22nd, Huntsville, AL, June 16-18, 1986. 9 p. refs
(AIAA PAPER 86-1549)

As part of the French CHARME research program to study high speed propellers, a 1-meter diameter propeller has been tested in the S1 Modane wind tunnel. The numerous measurements made during this test give precise data for the validation of calculation methods. Performances are compared to the results of a curved lifting line method, and analyzed with the help of pressure measurements made on spinner and nacelle. Pressures on the blades are compared to the results of a three-dimensional transonic Euler three-dimensional code. Future studies on counterrotating high speed propellers are also outlined. Author

A86-42709*# Lockheed-Georgia Co., Marietta.
EVALUATION OF PROPELLER/NACELLE INTERACTIONS IN THE PTA PROGRAM
A. S. ALJABRI, V. LYMAN, and R. J. PARKER (Lockheed-Georgia Co., Marietta) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 22nd, Huntsville, AL, June 16-18, 1986. 11 p. refs
(Contract NAS3-24339)
(AIAA PAPER 86-1552)

Advanced highly-loaded propellers are proposed to power transport aircraft that cruise at high subsonic speeds giving significant fuel savings over the equivalent turbofan engine. In order to realize these savings, the propeller must be installed so that the aerodynamics of the propeller/nacelle combination do not lead to excessive cyclic blade stresses or installation losses. The on-going, NASA sponsored, Propfan Test Assessment Program (PTA) has provided the first high-speed wind-tunnel data on an installed propfan complete with an inlet. This paper presents computational techniques that allow: (1) optimization of inlet plane location, (2) contouring of lip and cowl, and (3) estimation of propeller cyclic loads due to a nonuniform flowfield. These computational methods, in spite of the complexity of the configuration and the slipstream effects, provide predictions of aerodynamic performance which are in excellent agreement with wind-tunnel data. Author

A86-42740*# Pennsylvania State Univ., University Park.
A COMPARISON OF COMPUTATIONAL METHODS FOR THREE-DIMENSIONAL, TURBULENT TURBOMACHINERY FLOW FIELDS
K. R. KIRTLEY, M. WARFIELD, and B. LAKSHMINARAYANA (Pennsylvania State University, University Park) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 22nd, Huntsville, AL, June 16-18, 1986. 11 p. refs
(Contract NSG-3266)
(AIAA PAPER 86-1599)

A space-marching method and a time-marching method have been used to compute the three-dimensional turbulent flow in an end wall cascade of airfoils. Using an identical grid and turbulence model, the two codes were used to predict a variety of flow quantities. Predictions by the two methods are compared to each other and to experimental data. In general both methods predict measured quantities well, with a small edge in prediction accuracy going to the space-marching method. Secondary flow comparisons show the time-marching solution more accurately predicting the underturning of the flow in the outer portion of the end wall boundary layer while the space-marching method more accurately predicted the overturning of the flow very near the end wall. The prediction comparisons are discussed along with computational details and other attributes of the two methods. Author

A86-42753#
INITIAL PERFORMANCE EVALUATION OF 2DCD EJECTOR EXHAUST SYSTEMS
D. BROOKE, D. J. DUSA, A. P. KUCHAR, and B. M. ROMINE (General Electric Co., Cincinnati, OH) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 22nd, Huntsville, AL, June 16-18, 1986. 11 p.
(AIAA PAPER 86-1615)

An ejector nozzle system can furnish the cooling flow requirement of advanced nonaxisymmetric exhaust nozzles, perhaps yielding improvements in overall propulsion system performance. An equivalent area method is presently developed on the basis of an existing axisymmetric ejector nozzle prediction program for both nozzle performance (thrust coefficient) and the air-handling characteristics of the nonaxisymmetric designs considered. A scale test model program has been conducted to determine static performance and air handling for four different two-dimensional convergent/divergent exhaust systems. Results adequate for preliminary design studies are obtained. O.C.

A86-42756#
AXIAL-FLOW FAN STALLING BEHAVIOR WITH CIRCUMFERENTIAL INLET SECTORING
W. F. OBRIEN and B. M. CRAMER (Virginia Polytechnic Institute and State University, Blacksburg) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 22nd, Huntsville, AL, June 16-18, 1986. 15 p. refs
(AIAA PAPER 86-1622)

The development of rotating stall in an axial-flow compressor involves circumferential flows in front of the rotor. Experiments are reported in which sectoring struts were installed to interfere with the development of the circumferential flow in a single-stage compressor. On-rotor pressure transducers and stationary probes in front of and behind the rotor were employed to study the effect of the sectoring on the stalling behavior of the stage. Experiments were conducted with and without inlet flow distortion. The sectoring struts altered to stalling behavior of the compressor, in one case changing the rotating stall pattern to multiple cell, progressive stall, and preventing the development of single-cell rotating stall. A method for measurement of the number and rotational speed of the stall cells is reported. Author

A86-42760*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
A NUMERICAL ANALYSIS APPLIED TO HIGH ANGLE OF ATTACK THREE-DIMENSIONAL INLETS
D. P. HWANG (NASA, Lewis Research Center, Cleveland, OH) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 22nd, Huntsville, AL, June 16-18, 1986. 9 p. Previously announced in STAR as N86-24658. refs
(AIAA PAPER 86-1527)

The three-dimensional analytical methods used to analyze subsonic high angle of attack inlets are described. The methods are shown to be in good agreement with experimental results for various three-dimensional high angle of attack inlets. The methods are used to predict aerodynamic characteristics of scarf and slotted-lip inlets. E.A.K.

A86-42761#
CORRELATION OF THEORY AND EXPERIMENT FOR PROPFAN INLETS
V. LYMAN and J. P. HANCOCK (Lockheed Georgia Co., Marietta, GA) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 22nd, Huntsville, AL, June 16-18, 1986. 10 p. refs
(AIAA PAPER 86-1628)

Studies have indicated that the use of propfans can result in fuel savings of 20 to 25 percent relative to turbofans. Therefore, a program was initated to perform wind tunnel tests on a series of inlet models for advanced tractor, turboprop installations. Single-scoop and twin-scoop inlets and an annular inlet were tested to obtain inlet pressure recovery and distortion, external cowl surface pressures, external cowl forebody drag, and propeller blade stress data. All of the inlets were tested over a range of Mach numbers from .2 to .8 and a range of mass flow ratios. An analysis was undertaken for each of the tested propfan inlet configurations with Lockheed's QUADPAN panel program. Calculated nacelle surface pressures correlates well with experiment as long as the Mach number is low enough to preclude strong shocks on the nacelle and the scoop is large enough to be out of the low energy flow near the nacelle surface aft of the propeller spinner. The effect of the inlet interference flowfield on the propeller was calculated with Lockheed's PROPVRTX propeller analysis program. The results showed that displacing the inlet in the aft direction reduced the adverse effects on the propeller cyclic stresses. Measured propeller stress data support these results. The inlet location and contouring of the inlet lip are important design considerations that can be assessed by computational methods. Author

A86-42762*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
FLIGHT RESEARCH ON NATURAL LAMINAR FLOW NACELLES - A PROGRESS REPORT
E. C. HASTINGS, JR., J. A. SCHOENSTER (NASA, Langley Research Center, Hampton, VA), C. J. OBARA (PRC Kentron, Inc., Hampton, VA), and S. S. DODBELE (Vigyan Research Associates, Inc., Hampton, VA) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 22nd, Huntsville, AL, June 16-18, 1986. 9 p. refs
(AIAA PAPER 86-1629)

This paper presents a progress report on an ongoing flight experiment for natural laminar flow nacelles. The results given herein were obtained during the first phase of the experiment, in which an instrumented natural laminar flow nacelle fairing was flight tested in the presence of turbofan engine noise and a controlled noise source. The results indicate that with the controlled noise source off, natural laminar flow was measured as far aft as 37 percent of the fairing length. The transition front was irregular in contour, and the extent of natural laminar flow was significantly affected by the relative flow angle for the fairing. In addition to these test results, the paper discusses the results of some recent computational analyses to predict pressure distributions and transition location, and to explain some of the data trends. Comparisons between measured and predicted data indicate that the analytical methods successfully predicted trends for the baseline (no controlled noise source) studies. Author

A86-42822#
MULTI-STAGE COMPRESSOR AIRFOIL AERODYNAMICS. I - AIRFOIL POTENTIAL FLOW ANALYSIS
H. D. JOSLYN and R. P. DRING (United Technologies Research Center, East Hartford, CT) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 22nd, Huntsville, AL, June 16-18, 1986. 9 p. refs
(Contract N00014-84-C-0354)
(AIAA PAPER 86-1744)

An evaluation is made of the ability of potential flow theory to predict pressure distributions on rotor and stator airfoils in the unsteady, three-dimensional environment of a two-stage axial compressor. While excellent agreement is obtained between computational and experimental results for the core flow region, the unsteadiness and three-dimensionality produced by corner stall and rotor tip leakage can generate significant differences. It is further demonstrated, however, that the boundary layer calculations can be coupled to an approximate model for transitional and turbulent flow, together with an inferred level of freestream tubulence, in order to furnish reasonably accurate predictions of midspan loss. O.C.

A86-42824#
TIP LEAKAGE REDUCTION THROUGH TIP INJECTION IN TURBOMACHINES
M. J. POUAGARE, W. P. WEINHOLD (Duke University, Durham, NC), and K. LAZARUS AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 22nd, Huntsville, AL, June 16-18, 1986. 9 p. Army-sponsored research. refs
(AIAA PAPER 86-1746)

This paper describes an experimental study on tip leakage flow reduction through tip injection. A single blade was placed in the test section of a wind-tunnel with a gap between the tip of the blade and the top wall. Surface-streamline flow visualization, leakage flow visualization, blade static pressure measurements, and total pressure measurements behind the blade were performed in order to evaluate the effectiveness of tip injection in reducing leakage flow and losses. Two different patterns of injection were tested. It was found that the effectiveness of the tip injection depended on the injection angle and the injection-hole distribution. The study demonstrated the potential of tip injection in reducing leakage flow and losses as well as in energizing the end-wall boundary layer. Author

A86-42825#
REVERSE FLOW IN MULTISTAGE AXIAL COMPRESSORS
R. N. GAMACHE (USAF, Arnold Engineering Development Center, Arnold Air Force Station, TN) and E. M. GREITZER (MIT, Cambridge, MA) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 22nd, Huntsville, AL, June 16-18, 1986. 21 p. Research supported by United Technologies Corp. and USAF. refs
(AIAA PAPER 86-1747)

This paper reports an experimental study of multistage axial compressor operation under reverse flow conditions. The experiments were performed on a high hub-tip ratio (rh/rt = 0.88) three-stage low aspect ratio axial flow compressor. Complete sets of unstalled and stalled performance characteristics are presented for two builds with different blade stagger angles. The existence of a discontinuous flow mode transition from large scale asymmetry (rotating stall) to blade-to-blade periodic ('annulus stall') at a low reverse flow coefficient is documented. The nature of the annulus stall flow was determined from high response measurements of all three velocity components and pressure at several reverse flow coefficients, using data acquisition and processing techniques developed for flows with multiple sources of periodic unsteadiness. These blade passage resolved measurements provide the first detailed kinematic picture of the flowfield structure which exists in multistage axial compressors during reverse flow operation. The experimental results reveal that the flowfield is strongly three-dimensional. In addition, the upstream measurements show

a multilobed spinning acoustic disturbance pattern over a narrow range of reverse flow coefficients corresponding to a level of pressure rise equal to that in rotating stall. At this condition, the blade-to-blade periodicity disappears. Finally, it is shown that there are strong similarities in the structure of the reverse flow and rotating stall cell flowfields. Author

A86-43110
APPLICATION OF LASER-DUAL-FOCUS VELOCIMETRY IN A COUNTERFLOW
P. MORAES, JR. (Centro Tecnico Aerospacial, Instituto de Atividades Espaciais, Sao Jose dos Campos, Brazil) IN: Optical methods in dynamics of fluids and solids; Proceedings of the International Symposium, Liblice, Czechoslovakia, September 17-21, 1984 . Berlin and New York, Springer-Verlag, 1985, p. 75-82. DFG-supported research.

The flow field of a sonic jet exhausting against a supersonic mean stream was experimentally investigated using a dual-focus laser velocimeter. The experimental investigations were conducted in the 15 x 15-cm supersonic test section of the ILR wind tunnel for mainstream Mach number = 2.0 and total jet/mainstream pressure ratio = 2.0. The paper briefly describes the flow-measurement technique used and presents the flowfield details made possible through these measurements. A comparison of the measured quantities with theoretical results shows good agreement. Author

A86-43384
ROTATIONAL-TRANSLATIONAL SUBSONIC MOTION OF A FINITE-SPAN WING IN AN IDEAL GAS [VRASHCHATEL'NO-POSTUPATEL'NOE DOZVUKOVOE DVIZHENIE KRYLA KONECHNOGO RAZMAKHA V IDEAL'NOM GAZE]
S. V. MINEVICH Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 1, 1986, p. 34-38. In Russian. refs

An algorithm is presented for the computer calculation of the aerodynamic characteristics of a wing of arbitrary shape with an aspect ratio lambda not less than 2 in rotational-translational motion. The effect of gas compressibility is taken into account by a linearized equation. The accuracy of the calculations was checked on the example of wings of elliptical and rectangular planform in purely rotational or purely translational motion. The accuacy of the proposed method is compared with that of the methods of Karafoli (1956, 1960) and Belotserkovskii (1965). B.J.

A86-43401
MATHEMATICAL MODEL OF THE INTERACTION OF A SINGLE UNSTEADY SUPERSONIC JET WITH A MOVING BARRIER OF FINITE SIZE [MATEMATICHESKAIA MODEL' VZAIMODEISTVIIA ODINOCHNOI NESTATSIONARNOI SVERKHZVUHKOVOI STRUI S PODVIZHNOI PREGRADOI KONECHNYKH RAZMEROV]
A. V. KUZNETSOV Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 1, 1986, p. 99-102. In Russian. refs

The interaction of an unsteady supersonic jet with a moving barrier of finite size placed transverse to the flow is investigated with reference to the use of pulsating flows and gasdynamic generators in various industrial processes to intensify mass transfer. A method is developed for determining the actual geometrical characteristics of the barrier, its motion in the jet, and its influence on the formation of the flow pattern. It is concluded that the proposed mathematical model is valid for arbitrary intrachamber processes and axisymmetric barriers of complex profile. B.J.

A86-43402
EFFECT OF LONGITUDINAL-CONTOUR SHAPE ON THE AERODYNAMIC CHARACTERISTICS OF LIFTING BODIES AT SUPERSONIC AND HYPERSONIC FLIGHT VELOCITIES [VLIIANIE FORMY PRODOL'NOGO KONTURA NA AERODINAMICHESKIE KHARAKTERISTIKI NESUSHCHIKH KORPUSOV PRI SVERKHZVUKOVYKH I GIPERZVUKOVYKH SKOROSTIAKH POLETA]
I. I. MAZHUL Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 1, 1986, p. 102-105. In Russian.

The effect of flow expansion at the rear part of a lifting body on the aerodynamic characteristics is investigated for a fixed geometry of the front part of the body. It is shown that a change in the shape of the longitudinal contour of the upper or lower surface causes an increase in the size of the lifting body without substantial losses in the maximum lift-drag ratio. B.J.

A86-43403
INVESTIGATION OF THE STRUCTURE OF A SUPERSONIC JET ISSUING FROM A FREE-VORTEX NOZZLE BY MEANS OF PULSED HOLOGRAPHIC INTERFEROMETRY [ISSLEDOVANIE STRUKTURY SVERKHZVUKOVOI STRUI, ISTEKAIUSHCHEI IZ SVOBODNOVIKHREVOGO SOPLA, METODOM IMPUL'SNOI GOLOGRAFICHESKOI INTERFEROMETRII]
V. I. PANCHENKO, A. A. GILERSON, and B. S. VINOGRADOV Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 1, 1986, p. 105-107. In Russian.

Holographic interferometry was used to study the flow of a free-vortex jet beyond the nozzle in design conditions as well as when pressures on both boundaries of the jet differed from pressures on the nozzle section. The growth of the boundary layers on the jet boundaries is studied in both design and off-design conditions for different streamline curvatures of the ideal flow. B.J.

A86-43404
EXPERIMENTAL STUDY OF SUPERSONIC FLOW AROUND A SINGLE-STAGE WEDGE WITH CHEEKS AT SIDESLIP ANGLES [EKSPERIMENTAL'NOE ISSLEDOVANIE OBTEKANIIA ODNOSTUPENCHATOGO KLINA SO SHCHEKAMI SVERHZVUKOVYM POTOKOM NA UGLAKH SKOL'ZHENIIA]
V. V. DUGANOV, N. N. ZAKHAROV, and O. K. IVANOV Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 1, 1986, p. 107-110. In Russian. refs

Experimental results are presented concerning flow around a single-stage wedge with side cheeks (a configuration typical for two-dimensional supersonic intakes) at sideslip angles of 0, 5, and 10 deg. Experiments were carried out in a wind tunnel at a Mach number of 2.1, a Reynolds number of 10 to the 8th (for a characteristic dimension of 1 m), and a stagnation temperature of 288 K. The pressure distributions are examined, and the shock-wave configuration generated in the flow is discussed. B.J.

A86-43421
FEATURES OF THE FLOW STRUCTURE AROUND POLYGONAL LIFTING BODIES AT SUPERSONIC VELOCITIES [OSOBENNOSTI STRUKTURY OBTEKANIIA POLIGONAL'NYKH NESUSHCHIKH KORPUSOV PRI SVERKHZVUKOVYKH SKOROSTIAKH]
I. I. MAZHUL (AN SSSR, Institut Teoreticheskoi i Prikladnoi Mekhaniki, Novosibirsk, USSR) Akademiia Nauk SSSR, Sibirskoe Otdelenie, Izvestiia, Seriia Tekhnicheskie Nauki (ISSN 0002-3434), March 1986, p. 50-54. In Russian.

The flow characteristics around polygonal lifting bodies consisting of a combination of plane elements were studied experimentally at Mach numbers of 2, 3, and 4, and Reynolds numbers of 26 x 10 to the 6th, 33.5 x 10 to the 6th, and 50 x 10 to the 6th. It is shown that configurations of this type are characterized by the presence of internal shocks and boundary layer separation zones (induced by these shocks) on the lower surface. Another feature is the formation of conical vortex zones along swept lines of plane-face intersection on both upper and

lower surfaces. The behavior of these features is studied in relation to the flow conditions. B.J.

N86-28053*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
LASER FRINGE ANEMOMETRY FOR AERO ENGINE COMPONENTS
A. J. STRAZISAR 1986 54 p Presented at the 67th Symposium of the AGARD Propulsion and Energetics Panel on Advanced Instrumentation for Aero Engine Components, Philadelphia, Pa., 19-23 May 1986
(NASA-TM-88798; E-3135; NAS 1.15:88798) Avail: NTIS HC A02/MF A01 CSCL 01A

Advances in flow measurement techniques in turbomachinery continue to be paced by the need to obtain detailed data for use in validating numerical predictions of the flowfield and for use in the development of empirical models for those flow features which cannot be readily modelled numerically. The use of laser anemometry in turbomachinery research has grown over the last 14 years in response to these needs. Based on past applications and current developments, this paper reviews the key issues which are involved when considering the application of laser anemometry to the measurement of turbomachinery flowfields. Aspects of laser fringe anemometer optical design which are applicable to turbomachinery research are briefly reviewed. Application problems which are common to both laser fringe anemometry (LFA) and laser transit anemometry (LTA) such as seed particle injection, optical access to the flowfield, and measurement of rotor rotational position are covered. The efficiency of various data acquisition schemes is analyzed and issues related to data integrity and error estimation are addressed. Real-time data analysis techniques aimed at capturing flow physics in real time are discussed. Finally, data reduction and analysis techniques are discussed and illustrated using examples taken from several LFA turbomachinery applications. Author

N86-28054*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
MULTIAXIS AIRCRAFT CONTROL POWER FROM THRUST VECTORING AT HIGH ANGLES OF ATTACK
F. J. CAPONE and M. L. MASON Jun. 1986 51 p Presented at the AIAA 4th Applied Aerodynamics Conference, San Diego, Calif., 9-11 Jun. 1986
(NASA-TM-87741; NAS 1.15:87741; AIAA-86-1779) Avail: NTIS HC A03/MF A01 CSCL 01A

Extensive research programs conducted at the Langley Research Center have shown that thrust vectoring can be provided by multifunction (nonaxisymmetric) nozzles. Most of this research has been conducted on pitch vectoring at both static and forward flight conditions. Recent efforts have been aimed at evaluating yaw vectoring concepts at static (wind off) conditions. This paper summarizes results for three different twin-engine fighter configurations tested over a Mach number range of 0.15 to 2.47 at angles of attack up to 35 deg. The objective of these investigations was to determine the multiaxis control power characteristics provided by thrust vectoring. All three configurations employed two-dimensional convergent-divergent nozzles which provided pitch vectoring by differential deflection of the upper and lower nozzle divergent flaps. Three different means of yaw vectoring were tested: (1) a translating nozzle sidewall; (2) yaw flaps located in the nozzle sidewalls; and (3) canted nozzles. These investigations were conducted in the Langley 16-Foot Transonic Tunnel and the Lewis 10x10-Foot Supersonic Tunnel. Longitudinal and direction control power from thrust vectoring was greater than that provided by aerodynamic control effectors at low speed or at high angles of attack. Author

N86-28056*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
HOVER IN-GROUND-EFFECT TESTING OF A FULL-SCALE, TILT-NACELLE V/STOL MODEL
J. E. ESHLEMAN, M. R. DUDLEY, and C. J. SCHELL (Grumman Aerospace Corp., Bethpage, N.Y.) Feb. 1986 18 p Presented at the 14th AIAA Aerodynamic Testing Conference, West Palm Beach, Fla., 5-7 Mar. 1986
(NASA-TM-88218; A-86127; NAS 1.15:88218) Avail: NTIS HC A02/MF A01 CSCL 01A

A full-scale, tilt-nacelle V/STOL aircraft model was tested in hover at the National Full Scale Aerodynamics Complex (NFAC), NASA Ames Research Center. The model was powered by two TF-34 turbofan engines. It was tested at several ground heights and control deflections. Test technique and test setup were documented. Limited results show that: (1) a small change in control power with ground height was measured, and control power was found to be good over + or - 20 deg of horizontal vane deflection; (2) integrated fuselage undersurface pressures, when compared with the total model loads and measured thrust, defined the effect of the fountain and its related flow field on model forces and moments; and (3) there was no indication of hot gas ingestion during simulated takeoff in calm winds from wheels on deck ground height. Author

N86-28057*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
A PERSPECTIVE OF COMPUTATIONAL FLUID DYNAMICS
P. KUTLER May 1986 22 p Presented at the National Aerospace Lab., Tokyo, Japan, 20 Jun. 1986
(NASA-TM-88246; A-86224; NAS 1.15:88246) Avail: NTIS HC A02/MF A01 CSCL 01A

Computational fluid dynamics (CFD) is maturing, and is at a stage in its technological life cycle in which it is now routinely applied to some rather complicated problems; it is starting to create an impact on the design cycle of aerospace flight vehicles and their components. CFD is also being used to better understand the fluid physics of flows heretofore not understood, such as three-dimensional separation. CFD is also being used to complement and is being complemented by experiments. In this paper, the primary and secondary pacing items that govern CFD in the past are reviewed and updated. The future prospects of CFD are explored which will offer people working in the discipline challenges that should extend the technological life cycle to further increase the capabilities of a proven demonstrated technology. Author

N86-28060*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
ROTOR/WING AERODYNAMIC INTERACTIONS IN HOVER
F. F. FELKER and J. S. LIGHT May 1986 27 p Presented at the 42nd Annual Forum of the American Helicopter Society, 2-4 Jun. 1986
(NASA-TM-88255; A-86246; NAS 1.15:88255) Avail: NTIS HC A03/MF A01 CSCL 01A

An experimental and theoretical investigation of rotor/wing aerodynamic interactions in hover is described. The experimental investigation consisted of both a large-scale and small-scale test. A 0.658-scale, V-22 rotor and wing was used in the large-scale test. Wind download, wing surface pressure, rotor performance, and rotor downwash data from the large-scale test are presented. A small-scale experiment was conducted to determine how changes in the rotor/wing geometry affected the aerodynamic interactions. These geometry variations included the distance between the rotor and wing, wing incidence angle, and configurations both with the rotor axis at the tip of the wing (tilt rotor configuration) and with the rotor axis at the center of the wing (compound helicopter configuration). A wing with boundary-layer control was also tested to evaluate the effect of leading and trailing edge upper surface blowing on the wing download. A computationally efficient, semi-empirical theory was developed to predict the download on the wing. Finally, correlations between the theoretical predictions and test data are presented. Author

N86-28062*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
PATCHED-GRID CALCULATIONS WITH THE EULER AND NAVIER-STOKES EQUATIONS: THEORY AND APPLICATIONS
M. M. RAI Feb. 1986 105 p Presented at the Lecture Series on CFD, Rhode-St-Genese, Belgium, 3-7 Mar. 1986
(NASA-TM-88228; REPT-86112; NAS 1.15:88228) Avail: NTIS HC A06/MF A01 CSCL 01A

A patched-grid approach is one in which the flow region of interest is divided into subregions which are then discretized independently using existing grid generator. The equations of motion are integrated in each subregion in conjunction with patch-boundary schemes which allow proper information transfer across interfaces that separate subregions. The patched-grid approach greatly simplifies the treatment of complex geometries and also the addition of grid points to selected regions of the flow. A conservative patch-boundary condition that can be used with explicit, implicit factored and implicit relaxation schemes is described. Several example calculations that demonstrate the capabilities of the patched-grid scheme are also included. Author

N86-28064*# Old Dominion Coll., Norfolk, Va. Dept. of Mechanical Engineering and Mechanics.
AN INVESTIGATION OF THE FEASIBILITY OF ACTIVE BOUNDARY LAYER THICKENING FOR AIRCRAFT DRAG REDUCTION Final Report, period ending 3 Mar. 1986
R. L. ASH and C. KOODALATTUPURAM Apr. 1986 15 p
(Contract NAG1-121)
(NASA-CR-177133; NAS 1.26:177133) Avail: NTIS HC A02/MF A01 CSCL 01A

The feasibility of using a forward mounted windmilling propeller to extract momentum from the flow around an axisymmetric body to reduce total drag has been studied. Numerical calculations indicate that a net drag reduction is possible when the energy extracted is returned to an aft mounted pusher propeller. However, net drag reduction requires very high device efficiencies. Results of an experimental program to study the coupling between a propeller wake and a turbulent boundary layer are also reported. The experiments showed that a complex coupling exists and simple modes for the flow field are not sufficiently accurate to predict total drag. Author

N86-28066# Aeronautical Research Inst. of Sweden, Stockholm. Aerodynamics Dept.
TRANSONIC AND SUPERSONIC WIND TUNNEL TESTS ON SCHEMATIC MISSILE CONFIGURATIONS WITH TWO DIFFERENT NOSE LENGTHS
S. E. GUDMUNDSON and L. TORNGREN Sep. 1985 93 p
(Contract FMV-F-K-82223-75-007-07-001;
FMV-F-K-82223-76-001-21-001)
(FFA-TN-1984-62; ESA-86-97051) Avail: NTIS HC A05/MF A01

A wind tunnel investigation at transonic and supersonic speeds for schematic missile models including body alone, body-tail, body-wing, and body-wing-tail configurations was performed. The test gives symmetric force and moment coefficients for an angle of attack range of 0 to 24 deg at Mach numbers from 0.7 to 2.99. Two different ogival noses with length/diameter ratio 3.5 and 1.5 were used. The influence of the nose length on normal force, pitching moment and axial force was studied. Examples of effects on asymmetric coefficients are given. ESA

N86-28911*# New York Univ., New York. Courant Mathematics and Computing Lab.
COMPUTATION OF THE TRANSONIC FLOW ABOUT A SWEPT WING IN THE PRESENCE OF AN ENGINE NACELLE Research and Development Report
D. EOSS Dec. 1985 191 p
(Contract NAG2-345; DE-AC02-76ER-03077; NSF DMS-83-20430)
(NASA-CR-177113; NAS 1.26:177113; DOE/ER-03077/267)
Avail: NTIS CSCL 01A

A method was developed to model the effects of an engine nacelle on the transonic flow about a swept wing. The nacelle is modeled by adding an inhomogeneous term, which represents a source distribution, to the potential equation, which is solved by relaxation. The method is an extension of the design code FL22INV of Bauer, Garabedian, and McFadden, which was based on Caughy and Jameson's FLO22 and on the oblique wing code FLO16. In order to obtain a sharply defined obstacle using a source distribution on a finite difference grid, a small grid size near the source was used. This was accomplished through a mapping of the flow domain to the computational domain. Once the flow is computed, the size and position of the nacelle are found by tracing streamlines. The effect of the presence of an engine nacelle on the shock waves which form about a swept wing in transonic flight. Author

N86-28912*# Stanford Univ., Calif. Dept. of Aeronautics and Astronautics.
AN ANALYSIS OF BLADE VORTEX INTERACTION AERODYNAMICS AND ACOUSTICS
D. J. LEE Sep. 1985 173 p
(Contract NCC2-149)
(NASA-CR-177016; NAS 1.26:177016; SU-JIAA-TR-67) Avail: NTIS HC A08/MF A01 CSCL 01A

The impulsive noise associated with helicopter flight due to Blade-Vortex Interaction, sometimes called blade slap is analyzed especially for the case of a close encounter of the blade-tip vortex with a following blade. Three parts of the phenomena are considered: the tip-vortex structure generated by the rotating blade, the unsteady pressure produced on the following blade during the interaction, and the acoustic radiation due to the unsteady pressure field. To simplify the problem, the analysis was confined to the situation where the vortex is aligned parallel to the blade span in which case the maximum acoustic pressure results. Acoustic radiation due to the interaction is analyzed in space-fixed coordinates and in the time domain with the unsteady pressure on the blade surface as the source of chordwise compact, but spanwise non-compact radiation. Maximum acoustic pressure is related to the vortex core size and Reynolds number which are in turn functions of the blade-tip aerodynamic parameters. Finally noise reduction and performance are considered. Author

N86-28913*# Stanford Univ., Calif. Dept. of Aeronautics and Astronautics.
ANALYTICAL OBSERVATIONS ON THE AERODYNAMICS OF A DELTA WING WITH LEADING EDGE FLAPS
S. OH and D. TAVELLA Mar. 1986 69 p
(Contract NCC2-74)
(NASA-CR-177022; NAS 1.26:177022; SU-JIAA-TR-74) Avail: NTIS HC A04/MF A01 CSCL 01A

The effect of a leading edge flap on the aerodynamics of a low aspect ratio delta wing is studied analytically. The separated flow field about the wing is represented by a simple vortex model composed of a conical straight vortex sheet and a concentrated vortex. The analysis is carried out in the cross flow plane by mapping the wing trace, by means of the Schwarz-Christoffel transformation into the real axis of the transformed plane. Particular attention is given to the influence of the angle of attack and flap deflection angle on lift and drag forces. Both lift and drag decrease with flap deflection, while the lift-to-drag ratioe increases. A simple coordinate transformation is used to obtain a closed form expression for the lift-to-drag ratio as a function of flap deflection. The main effect of leading edge flap deflection is a partial suppression of the separated flow on the leeside of the wing. Qualitative comparison with experiments is presented, showing agreement in the general trends. Author

N86-28914*# Stanford Univ., Calif. Dept. of Aeronautics and Astronautics.
A STUDY OF THE FACTORS AFFECTING BOUNDARY LAYER TWO-DIMENSIONALITY IN WIND TUNNELS
R. D. MEHTA and P. H. HOFFMANN May 1986 29 p
(Contract NCC2-294)
(NASA-CR-177023; NAS 1.26:177023; SU-JIAA-TR-66) Avail: NTIS HC A03/MF A01 CSCL 01A

The effect of screens, honeycombs, and centrifugal blowers on the two-dimensionality of a boundary layer on the test section floors of low-speed blower tunnels is studied. Surveys of the spanwise variation in surface shear stress in three blower tunnels revealed that the main component responsible for altering the spanwise properties of the test section boundary layer was the last screen, thus confirming previous findings. It was further confirmed that a screen with varying open-area ratio, produced an unstable flow. However, contrary to popular belief, it was also found that for given incoming conditions and a screen free of imperfections, its open-area ratio alone was not enough to describe its performance. The effect of other geometric parameters such as the type of screen, honeycomb, and blower were investigated. In addition, the effect of the order of components in the settling chamber, and of wire Reynolds number were also studied. Author

N86-28915*# Stanford Univ., Calif. Dept. of Aeronautics and Astronautics.
THE LIFT OF SHARP-LEADING-EDGED DELTA WINGS WITH BLOWING
D. A. TAVELLA Dec. 1985 22 p
(Contract NCC2-341)
(NASA-CR-176967; NAS 1.26:176967; JIAA-TR-68) Avail: NTIS HC A02/MF A01 CSCL 01A

An analysis of the lift augmentation due to a thin jet of air issuing from a slot along the leading edge of a delta wing is presented. The problem is treated with an extension of the method of Brown and Michael, representing the separated flow on the lee side of the wing by a pair of concentrated vortices and corresponding feeding sheets. It is assumed that the jet is not affected by Coanda forces. The analysis produces qualitative agreement with experiments. Author

N86-28916*# California Polytechnic State Univ., San Luis Obispo. Dept. of Aeronautical Engineering.
THE USE OF A PANEL CODE ON HIGH LIFT CONFIGURATIONS OF A SWEPT FORWARD WING Final Report, 31 Sep. 1983 - 31 Mar. 1985
J. S. SCHEIB and D. R. SANDLIN 31 Mar. 1985 70 p
(Contract NCC2-255)
(NASA-CR-176968; NAS 1.26:176968) Avail: NTIS HC A04/MF A01 CSCL 01A

A study was done on high lift configurations of a generic swept forward wing using a panel code prediction method. A survey was done of existing codes available at Ames, frow which the program VSAERO was chosen. The results of VSAERO were compared with data obtained from the Ames 7- by 10-foot wind tunnel. The results of the comparison in lift were good (within 3.5%). The comparison of the pressure coefficients was also good. The pitching moment coefficients obtained by VSAERO were not in good agreement with experiment. VSAERO's ability to predict drag is questionable and cannot be counted on for accurate trends. Further studies were done on the effects of a leading edge glove, canards, leading edge sweeps and various wing twists on spanwise loading and trim lift with encouraging results. An unsuccessful attempt was made to model spanwise blowing and boundary layer control on the trailing edge flap. The potential results of VSAERO were compared with experimental data of flap deflections with boundary layer control to check the first order effects. Author

N86-28917*# California Polytechnic State Univ., San Luis Obispo. Dept. of Aeronautical Engineering.
IDENTIFICATION OF LINEARIZED EQUATIONS OF MOTION FOR THE FIXED WING CONFIGURATION OF THE ROTOR SYSTEMS RESEARCH AIRCRAFT Final Report, 19 Mar. 1985 - 19 Mar. 1986
D. L. BALOUGH and D. R. SANDLIN Mar. 1986 98 p
(Contract NCC2-258)
(NASA-CR-176977; NAS 1.26:176977) Avail: NTIS HC A05/MF A01 CSCL 01A

The purpose of this report is to establish linear, decoupled models of rigid body motion for the fixed wing configuration of the Rotor Systems Research Aircraft (RSRA). Longitudinal and lateral control surface fixed linear models were created from aircraft time histories using current system identification techniques. Models were obtained from computer simulation at 160 KCAS and 200 KCAS, and from flight data at 160 KCAS. Comparisons were performed to examine modeling accuracy, variation of dynamics with airspeed and correlation of simulation and flight data results. The results showed that the longitudinal and lateral linear models accurately predicted RSRA dynamics. The flight data results showed that no significant handling qualities problems were present in the RSRA fixed wing aircraft at the flight speed tested. Author

N86-28918*# Kansas Univ. Center for Research, Inc., Lawrence.
WAKE SHAPE AND ITS EFFECTS ON AERODYNAMIC CHARACTERISTICS
H. EMDAD and C. E. LAN Hampton, Va. NASA Jul. 1986 116 p
(Contract NAG1-134)
(NASA-CR-178118; NAS 1.26:178118) Avail: NTIS HC A06/MF A01 CSCL 01A

The wake shape under symmetrical flight conditions and its effects on aerodynamic characteristics are examined. In addition, the effect of wake shape in sideslip and discrete vortices such as strake or forebody vortex on lateral characteristics is presented. The present numerical method for airplane configurations, which is based on discretization of the vortex sheet into vortex segments, verified the symmetrical and asymmetrical roll-up process of the trailing vortices. Also, the effect of wing wake on tail planes is calculated. It is concluded that at high lift the assumption of flat wake for longitudinal and lateral-directional characteristics should be reexamined. Author

N86-28919*# California Polytechnic State Univ., San Luis Obispo. Dept. of Aeronautical Engineering.
A COMPARISON OF COMPUTER-GENERATED LIFT AND DRAG POLARS FOR A WORTMANN AIRFOIL TO FLIGHT AND WIND TUNNEL RESULTS Final Report
A. H. BOWERS and D. R. SANDLIN Jun. 1984 46 p
(NASA-CR-176963; NAS 1.26:176963) Avail: NTIS HC A03/MF A01 CSCL 01A

Computations of drag polars for a low-speed Wortmann sailplane airfoil are compared to both wind tunnel and flight results. Excellent correlation is shown to exist between computations and flight results except when separated flow regimes were encountered. Wind tunnel transition locations are shown to agree with computed predictions. Smoothness of the input coordinates to the PROFILE airfoil analysis computer program was found to be essential to obtain accurate comparisons of drag polars or transition location to either the flight or wind tunnel results. Author

N86-28920*# California Polytechnic State Univ., San Luis Obispo. Dept. of Aeronautical Engineering.
COMPARISON OF THEORETICAL AND FLIGHT-MEASURED LOCAL FLOW AERODYNAMICS FOR A LOW-ASPECT-RATIO FIN Final Report, 31 Oct. 1980 - 31 Oct. 1984
J. B. JOHNSON and D. R. SANDLIN Oct. 1984 30 p
(Contract NCC4-1)
(NASA-CR-176995; NAS 1.26:176995) Avail: NTIS HC A03/MF A01 CSCL 01A

Flight test and theoretical aerodynamic data were obtained for a flight test fixture mounted on the underside of an F-104G aircraft. The theoretical data were generated using two codes, a two dimensional transonic code called Code H, and a three dimensional subsonic and supersonic code call wing-body. Pressure distributions generated by the codes for the flight test fixture as well as boundary layer displacement thickness generated by the two dimensional code were compared to the flight test data. The two dimensional code pressure distributions compared well except at the minimum pressure point and trailing edge. Shock locations compared well except at high transonic speeds. The three dimensional code pressure distributions compared well except at the trailing edge of the flight test fixture. The two dimensional code does not predict displacement thickness of the flight test fixture well. Author

N86-28921*# Ohio State Univ., Columbus. Dept. of Aeronautical and Astronautical Engineering.
EXPERIMENTAL ANALYSES OF TRAILING EDGE FLOWS Final Technical Report
S. L. PETRIE and D. S. EMMER Jun. 1984 96 p
(Contract NSG-2298)
(NASA-CR-176904; NAS 1.26:176904) Avail: NTIS HC A05/MF A01 CSCL 01A

An experimental study of several of the trailing edge and wake turbulence properties for a NACA 64A010 airfoil section was completed. The experiment was conducted at the Ohio State University Aeronautical and Astronautical Research Laboratory in the 6 inch X 22 inch transonic wind tunnel facility. The data were obtained at a free stream Mach number of 0.80 and a flow Reynolds number (based on chord length) of 5 million. The principle diagnostic tool was a dual-component laser Doppler velocimeter. The experimental data included surface static pressures, chordwise and vertical mean velocities, RMS turbulence intensities, local flow angles, and a determination of turbulence kinetic energy in the wake. Two angles of attack (0 and 2 degrees) were investigated. At these incidence angles, four flow field surveys were obtained ranging in position from the surface of the airfoil, between the transonic shock and the trailing edge, to the far-wake. At both angles of attack, the turbulence intensities and turbulence kinetic energy were observed to decay in the streamwise direction. In the far wake, for the non-lifting case, the turbulence intensities were nearly isotropic. For the two degree case, the horizontal component of the turbulence intensity was observed to be substantially higher than the vertical component. Author

N86-28922*# Stanford Univ., Calif. Dept. of Aeronautics and Astronautics.
MEASUREMENTS ON WING-TIP BLOWING
D. TAVELLA, N. WOOD, and P. HARRITS Jun. 1985 41 p
(Contract NCC2-271)
(NASA-CR-176930; NAS 1.26:176930; JIAA-TR-64) Avail: NTIS HC A03/MF A01 CSCL 01A

The aerodynamics of a rectangular wing with a jet exhausting in the spanwise direction from the tips has been explored experimentally. By effectively changing the span of the wing as well as outwardly displacing the tip vortices, such jets can induce aerodynamic forces that could be used for roll and lateral control of aircraft. The concept has been investigated for a variety of jet intensities, angles of attack, and aspect ratios. The results appear to confirm theoretically predicted scaling laws for lift gain and moment generation due to blowing. Author

N86-28923*# Stanford Univ., Calif. Dept. of Aeronautics and Astronautics.
A THEORY FOR LATERAL WING-TIP BLOWING
D. TAVELLA and L. ROBERTS Jun. 1985 40 p
(Contract NCC2-271)
(NASA-CR-176931; NAS 1.26:176931; JIAA-TR-60) Avail: NTIS HC A03/MF A01 CSCL 01A

The concept of lateral blowing consists in utilizing thin jets of air, which are ejected in the spanwise direction from slots at the tips of straight and swept wings, or along the leading edges of delta wings, to generate aerodynamic forces without the assistance of deflecting solid surfaces. For weak intensities of blowing the so-generated forces could be used for roll and lateral control of aircraft. In this work a theory for this concept as applied to straight wings is presented, revealing the analytical relationship between blowing and aerodynamic forces. The approach is based on perturbing the span of an elliptically loaded wing. Scaling laws involving blowing intensity, aspect ratio, and angle of attack are derived and compared with experiments. It is concluded that this concept has potential as a novel roll and lateral control device. Author

N86-28924*# Waterloo Univ. (Ontario). Dept. of Applied Mathematics.
CRITICAL EVALUATION OF THE UNSTEADY AERODYNAMICS APPROACH TO DYNAMIC STABILITY AT HIGH ANGLES OF ATTACK Final Report
W. H. HUI Feb. 1985 46 p
(Contract NAGW-575)
(NASA-CR-177104; NAS 1.26:177104; WRI-PRO-308-07) Avail: NTIS HC A03/MF A01 CSCL 01A

Bifurcation theory is used to analyze the nonlinear dynamic stability characteristics of an aircraft subject to single-degree-of-freedom. The requisite moment of the aerodynamic forces in the equations of motion is shown to be representable in a form equivalent to the response to finite amplitude oscillations. It is shown how this information can be deduced from the case of infinitesimal-amplitude oscillations. The bifurcation theory analysis reveals that when the bifurcation parameter is increased beyond a critical value at which the aerodynamic damping vanishes, new solutions representing finite amplitude periodic motions bifurcate from the previously stable steady motion. The sign of a simple criterion, cast in terms of aerodynamic properties, determines whether the bifurcating solutions are stable or unstable. For the pitching motion of flat-plate airfoils flying at supersonic/hypersonic speed and for oscillation of flaps at transonic speed, the bifurcation is subcritical, implying either the exchanges of stability between steady and periodic motion are accompanied by hysteresis phenomena, or that potentially large aperiodic departures from steady motion may develop. Author

N86-28925*# National Aeronautics and Space Administration, Washington, D.C.
AERODYNAMICS OF THE VIGGEN 37 AIRCRAFT. PART 1: GENERAL CHARACTERISTICS AT LOW SPEED
K. KARLING Jun. 1986 145 p Transl. into ENGLISH of the book "Flygplan 37:s Aerodynamik - Part 1: Allmaent egenskaper vid Laaga Farter" Linkoeping, Sweden, SAAB-Scania, 1975 96 p Transl. by Kanner (Leo) Associates, Redwood City, Calif.
(Contract NASW-4005)
(NASA-TM-88403; NAS 1.15:88403) Avail: NTIS HC A07/MF A01 CSCL 01A

A description of the aerodynamics of the Viggen 37 and its performances, especially at low speeds is presented. The aerodynamic requirements for the design of the Viggen 37 aircraft are given, including the basic design, performance requirement, and aerodynamic characteristics, static and dynamic load test results and flight test results. The Viggen 37 aircraft is designed to be used for air attack, surveillance, pursuit, and training applications. It is shown that this aircraft is suitable for short runways, and has good maneuvering, acceleration, and climbing characteristics. The design objectives for this aircraft were met by

utilizing the effect produced by the interference between two triangular wings, positioned in tandem. Author

N86-28926# Oregon State Univ., Corvallis. Dept. of Mechanical Engineering.
FIRST ORDER ANALYSIS OF THE EFFECT OF PITCHING ON THE DRAG COEFFICIENT
R. E. WILSON and J. A. NEFF Nov. 1985 39 p
(Contract DE-AC04-76DP-00789)
(DE86-006324; SAND-85-7003) Avail: NTIS HC A03/MF A01

A first order analysis was made for the drag coefficient of a pitching NACA 0015 airfoil below stall. The inviscid velocity ditribution for a translating NACA 0015 airfoil was superimposed with the additional circulation velocity for a pitching ellipse. The resulting velocity distribution was used to numerically integrate a momentum/boundary layer formulation to obtain the drag coefficient. For both laminar and turbulent boundary layers it was found that the effect of pitching on the drag coefficient can be approximated by a shift in angle of attack. The shift angle was found to be a linear function of the pitching velocity and to be less than the induced angle of attack caused by the pitching. DOE

N86-28927# Office National d'Etudes et de Recherches Aerospatiales, Paris (France). Dir. Scientifique de la Resistance des Structures.
EXTENSION OF A TRANSONIC THREE-DIMENSIONAL UNSTEADY SMALL PERTURBATION COMPUTING METHOD Final Report [DEVELOPPEMENT DU CODE DE CALCUL DE PETITES PERTURBATIONS TRANSSONIQUES INSTATIONNAIRES EN TRIDIMENSIONNEL]
P. MULAK Aug. 1985 37 p In FRENCH
(Contract DRET-84-34-001)
(ONERA-RTS-23/3064-RY-048-R; ESA-86-97199) Avail: NTIS HC A03/MF A01

A method used for rigid models in unsteady flow is extended to a flexible model to compute the vibration modes. A flexible supercritical wing profile model, that of the A-310 aircraft, was tested in a wind tunnel and the results were compared to computation. The results are in good agreement, but differences with other computing methods for the first four symmetric vibration modes are discussed. ESA

N86-28928# National Aerospace Lab., Amsterdam (Netherlands). Fluid Dynamics and Informatics Div.
DESIGN OF TRANSONIC AIRFOILS WITH GIVEN PRESSURE, SUBJECT TO GEOMETRIC CONSTRAINTS
J. M. J. FRAY, J. W. SLOOFF, J. W. BOERSTOEL, and A. KASSIES 13 Jul. 1984 36 p
(NLR-TR-84064-U; B8660349; ESA-86-97504) Avail: NTIS HC A03/MF A01

An iterative method for the design of airfoils having a prescribed pressure distribution in subsonic or transonic flow is described. In each iteration step, the difference between the current and a target pressure distributions (residual) is determined by a multigrid finite volume full-potential code. Corrections to the geometry driving the pressure residual to zero are determined by a global, inverse, thin-airfoil theory for the subsonic part of the flow field, and by a local, inverse, wavy-wall theory for the supersonic part. The geometry correction is formulated as a minimization problem in the sense that pressure distribution and geometry requirements may be balanced in a weighted least squares sense. ESA

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AIR TRANSPORTATION AND SAFETY

Includes passenger and cargo air transport operations; and aircraft accidents.

A86-40228
THE MARKET PRICE FOR AIR SAFETY
H. A. HOPKINS International Journal of Aviation Safety (ISSN 0264-6803), vol. 3, Sept. 1985, p. 181-186.

An evaluation is made of the extent to which the financial and market objectives that are preeminent in the deregulated commercial environment in which many airlines now compete may affect flight safety. A comparison of fatal accident rates per million flights for the 1973-1984 period with the per capita income of various countries in 1981 appears to imply some relationship between the amount of money available and the rate of fatal accidents. Attention is given to the apportionment of responsibility for safety to airline management, the deregulated airline environment in the U.S. and questions it has raised concerning corner-cutting, and the monitoring of management performance. O.C.

A86-40565
REGULATION BY THE CIVIL AVIATION AUTHORITY OF AIR SAFETY IN THE UNITED KINGDOM
G. WHITE (Civil Aviation Authority, London, England) International Journal of Aviation Safety (ISSN 0264-6803), vol. 3, Dec. 1985, p. 238-241, 302.

The functions of the Civil Aviation Authority (CAA) related to air safety in the United Kingdom are described. The CAA requires the registration and marking of aircraft, and evaluates the operation and training manuals submitted by public transport aircraft. The requirements for issuing of air operator certificates and airworthiness certificates are discussed. The licensing of flight crews, air traffic controllers, and airfields is examined. The CAA has full authority to enforce its regulations by refusing, revoking, or suspending certificates and licenses. It is also necessary for the CAA to provide air navigation services, which consist of information, directions, and facilities furnished, issued, or provided in connection with the navigation or movement of aircraft. I.F.

A86-40567
POLICING AVIATION SAFETY IN THE NETHERLANDS
R. M. SCHNITKER (Netherlands National Police Force, Aviation Investigation Dept.) International Journal of Aviation Safety (ISSN 0264-6803), vol. 3, Dec. 1985, p. 245-254.

The monitoring of aviation safety by the aviation branch of the Dutch National Police Force is discussed. The police force is required to examine aircraft registrations and pilot qualifications at airports and other aviation locations. The procedures involved in preventing and controlling aviation accidents are described. The checking of cargo to ensure proper transportation of dangerous materials and of passengers to prevent potential aviation crimes is examined. The National Police Force coordinates their activities with local police forces, public prosecutors, and the government's aviation department in order to assure aviation safety. I.F.

A86-41034#
PROTECTING ELECTRONICS AGAINST LIGHTNING GETS HARDER
E. J. LERNER Aerospace America (ISSN 0740-722X), vol. 24, May 1986, p. 30-32, 34.

The problem of protecting aircraft electronics from lightning strikes, when electronics are becoming both more vulnerable and more central to flight safety, is considered. Graphite composites are replacing aluminum in the skin of many aircraft, and as a result the interior electronics are not so well shielded from the 20-30-kA current of even an average lightning strike. It is noted that the FAA will soon introduce testing standards - based on present voluntary tests - for certifying that the electronics of a

plane are fully shielded against lightning. A Boeing simulator will send 200-kA pulses (equal to very large lightning bolts) through full-scale aircraft. The two basic methods of protecting electronics shielding with metal and electronic isolation from induced charges - are both discussed. D.H.

A86-41275
PILOT REPORT - B-1B
M. A. KENNY (USAF, Dyess AFB, TX) Air Force Magazine (ISSN 0730-6784), vol. 69, June 1986, p. 58-62.

An account is given of the cockpit environment, flight control activities and an in-flight refueling session aboard the B-1B bomber, whose properties in these various functions derive from the extensive use of computerized control. The aircraft possesses the agility to maneuver between hills, as well as the ability to fly just above any type of terrain, in any weather. Attention is given to the crew activities associated with a low level bombing run at the Dyess Air Force Base test range. O.C.

A86-41694*# Massachusetts Inst. of Tech., Cambridge.
MEASUREMENT OF ICE GROWTH DURING SIMULATED AND NATURAL ICING CONDITIONS USING ULTRASONIC PULSE-ECHO TECHNIQUES
R. J. HANSMAN, JR. and M. S. KIRBY (MIT, Cambridge, MA) Journal of Aircraft (ISSN 0021-8669), vol. 23, June 1986, p. 492-498. FAA-supported research. Previously cited in issue 07, p. 842, Accession no. A86-19860. refs
(Contract NGL-22-009-640)

A86-41695*# National Severe Storms Lab., Norman, Okla.
LIGHTNING STRIKES TO A NASA AIRPLANE PENETRATING THUNDERSTORMS AT LOW ALTITUDES
V. MAZUR (NOAA, National Severe Storms Laboratory, Norman, OK), B. D. FISHER (NASA, Langley Research Center, Hampton, VA), and J. C. GERLACH (NASA, Wallops Space Flight Center, Wallops Island, VA) Journal of Aircraft (ISSN 0021-8669), vol. 23, June 1986, p. 499-505. Previously cited in issue 07, p. 841, Accession no. A86-19637. refs

A86-42423
FROM A STRIKE TO A KILL
M. SMITH New Scientist (ISSN 0028-6664), vol. 110, May 29, 1986, p. 44-47.

Numerous bird collisions with aircraft have occurred at major airports over the past quarter century, sometimes resulting in loss of life and aircraft. The birds are sucked into the engines or collide with various parts of the aircraft. Although gulls comprise 40 percent of the problem species, difficulties also arise with lapwing (26 percent), partridges, snipes, kestrels, swallows, skylarks, etc. Wide-bodied jets are struck seven times as frequently as older, narrow-bodied aircraft. Personnel at Kennedy Airport and other airports use recorded distress calls, pyrotechnic devices and a shotgun to drive of birds. A persistent difficulty in keeping birds away is garbage dumps close to airports providing bountiful food for birds. The most effective method for warding off birds has been to keep grass around runways cut no shorter than 20 cm. The technique has been enhanced by removing earthworms from runways during rainy periods so that birds aren't drawn to the food. M.S.K.

N86-28068*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
TIME-BASED AIR TRAFFIC MANAGEMENT USING EXPERT SYSTEMS
L. TOBIAS and J. L. SCOGGINS Apr. 1986 59 p
(NASA-TM-88234; A-86188; NAS 1.15:88234) Avail: NTIS HC A04/MF A01 CSCL 07G

A prototype expert system was developed for the time scheduling of aircraft into the terminal area. The three functions of the air traffic control schedule advisor are as follows: first, for each new arrival, it develops an admissible flight plan for that aircraft. Second, as the aircraft progresses through the terminal area, it monitors deviations from the flight plan and provides advisories to return the aircraft to its assigned schedule. Third, if major disruptions such as missed approaches occur, it develops a revised plan. The advisor is operational on a Symbolics 3600, and is programed in MRS (a logic programming language), Lisp, and FORTRAN. Author

N86-28069# National Transportation Safety Board, Washington, D. C. Bureau of Accident Investigation.
AIRCRAFT ACCIDENT REPORT: CHINA AIRLINES BOEING 747-SP, N4522V 300 NAUTICAL MILES NORTHWEST OF SAN FRANCISCO, CALIFORNIA, FEBRUARY 19, 1985
29 Mar. 1986 48 p
(PB86-910403; NTSB-AAR-86-03) Avail: NTIS HC A03/MF A01; also available on subscription, North American continent HC $60.00/year; all others write for quote CSCL 01B

About 1016 Pacific standard time February 19, 1985, China Airlines Flight 006, a Boeing 747 SP-09, enroute to Los Angeles, California from Taipei, Taiwan, suffered an inflight upset. The flight from Taipei to about 300 nmi northwest of San Francisco was uneventful and the airplane was flying at about 41,000 feet mean sea level when the No. 4 engine lost power. The National Transportation Safety Board determines that the probable cause of the accident was the captain's preoccupation with an inflight malfunction and his failuare to monitor properly the airplane's flight instruments which resulted in his losing control of the airplane. Contributing to the accident was the captain's over-reliance on the autopilot after the loss of thrust on the No. 4 engine. GRA

N86-28070# National Transportation Safety Board, Washington, D. C. Bureau of Field Operations.
AIRCRAFT ACCIDENT REPORTS: BRIEF FORMAT US CIVIL AND FOREIGN AVIATION, ISSUE NUMBER 10 OF 1984 ACCIDENTS
16 Dec. 1985 406 p
(PB86-916906; NTSB-AAB-86-06) Avail: NTIS HC A18/MF A01; also available on subscription, North American continent HC $185.00/year; all others write for quote CSCL 01B

Selected aircraft accident reports in brief format occurring in U.S. civil and foreign aviation operations during Calendar Year 1984 are given. Approximately 200 general aviation and air carrier accidents represent a random selection. The facts, conditions, circumstances and probable cause(s) for each accident are given. GRA

N86-28929# National Transportation Safety Board, Washington, D. C.
ANNUAL REVIEW OF AIRCRAFT ACCIDENT DATA. US AIR CARRIER OPERATIONS: CALENDAR YEAR 1982
1982 111 p
(PB86-212529; NTSB-ARC-86-01) Avail: NTIS HC A06/MF A01

The record of aviation accidents involving revenue operations of U.S. Air Carriers are presented, including Commuter Air Carriers and On Demand Air Taxis for calender year 1982. In 1979 and prior years, accidents involving the smaller aircraft used by Commuters and On Demand Air Taxis were reported in annual reviews of general aviation accidents. Three major sections are presented according to the federal regulations under which the flight was conducted: 14 CFR 121, 125, 127, Scheduled 14 CFR 135. In each section, tables are presented to describe the losses and characteristics of 1982 accidents to enable comparison with pior years. Author

04

AIRCRAFT COMMUNICATIONS AND NAVIGATION

Includes digital and voice communication with aircraft; air navigation systems (satellite and ground based); and air traffic control.

A86-40116#
INTEGRATED NAVIGATION, COMMUNICATION, AND SURVEILLANCE SYSTEMS BASED ON STANDARD DISTANCE MEASURING EQUIPMENT
A. BECKER (DFVLR, Institut fuer Flugfuehrung, West Germany) (International Council of the Aeronautical Sciences, Congress, 14th, Toulouse, France, September 9-14, 1984, Proceedings. Volume 2, p. 1225/a-1225/k) Journal of Aircraft (ISSN 0021-8669), vol. 23, May 1986, p. 406-414. Previously cited in issue 22, p. 3183, Accession no. A84-45064. refs

A86-40227
AIRPORT SURFACE NAVIGATION AND TRAFFIC CONTROL
W. L. THOMPSON (Racal Avionics, Ltd., New Malden, England) International Journal of Aviation Safety (ISSN 0264-6803), vol. 3, Sept. 1985, p. 171-174.

In order to refine the control of airport surface environments to the same degree as flight environments, ATC calls for ground movement radars currently becoming available with all-weather performance and low capital costs. There remain, however, problems with radio crosstalk, interference, and various emergencies that can endanger ATC operations in a crowded airport. The development of surface navigation systems giving each pilot a visual display of the airport layout is therefore recommended. O.C.

A86-40229
COMPUTERISATION OF AIR INFORMATION SERVICES IN FRANCE
R. WALLE (Service de l'Information Aeronautique, Athis-Mons, France) International Journal of Aviation Safety (ISSN 0264-6803), vol. 3, Sept. 1985, p. 188-191, 196.

A development history and performance evaluation account is given of France's computerization of ATC data since 1979. In 1983, an aviation data base was established for the automatic editing of ATC documents and the communication of aeronautical restrictions. Attention is given to the system built for automated processing of notices to airmen, which both receives and transmits data and may be extended to such other functions as flight plan processing and the compilation of meteorological data. O.C.

A86-40230
THE FRENCH AIR TRAFFIC CONTROL SYSTEM TODAY - A PARADOX
J.-P. BERNARD International Journal of Aviation Safety (ISSN 0264-6803), vol. 3, Sept. 1985, p. 192-196.

An evaluation is made of those aspects of the French ATC system which appear to be either more sophisticated or more backward than is currently the case in West European countries of comparable economic importance and technological advancement. The French ATC system is noted to suffer from a lack of uniform radar control for en route and approach segments of flight, giving rise to incompatibilities between both systems and working methods at various air control centers and between the centers and airport approaches. Attention is given to the French automatic air traffic coordinator, which is based on a distributed minicomputer architecture. O.C.

A86-40569
RADIO TELEPHONY - A CASE FOR GROWING CONCERN
H. M. VERMEULEN International Journal of Aviation Safety (ISSN 0264-6803), vol. 3, Dec. 1985, p. 274-276.

The problems with and recommendations for improving aircraft communications are analyzed. The difficulties encountered in international radio communications due to language differences are discussed. The need to eliminate unnecessary distractions in the cockpit and to reduce verbal communications and traffic on busy frequencies is examined. The role of ICAO in improving aircraft communications and developing a better infrastructure is described. The use of secondary surveillance radar mode-S, which has a digital data link and provides a traffic display for the pilots, and the removal of HF frequencies as the means of civil aircraft communication are proposed as methods for enhancing aircraft communications. I.F.

A86-40570
LANGUAGE PROBLEMS IN AIR TRAFFIC CONTROL
L. F. LEVESON International Journal of Aviation Safety (ISSN 0264-6803), vol. 3, Dec. 1985, p. 277-279.

The problems encountered in radio telephony (R/T) communications due to language difficulties are described. It is observed that rapid delivery of information, pronounced accents, and the use of slang and colloquial phrases hinder aircraft communications. The need for pilots and air traffic controllers (ATCs) to speak proper English and precisely utilize R/T phraseology is discussed. It is recommended that English be made the official R/T language, a higher standard of English proficiency stressing pronounciation and phonetics be required of pilots and ATCs, language training should take place in the area the trainee will be operating, and radio traffic be frequently monitored. I.F.

A86-41335
DESIGN TECHNIQUE TO REDUCE EFFECTS OF TIDAL VARIATIONS ON AN ILS GLIDE SLOPE SYSTEM
V. UNGVICHIAN (Florida Atlantic University, Boca Raton) Electronics Letters (ISSN 0013-5194), vol. 22, April 24, 1986, p. 478, 479.

A 330 MHz null-reference glide slope system design technique to minimize the reflecting surface variations is introduced. The runaway approach end of the site selected to test this design is over an ocean. Since the ocean forms part of the reflecting surface of the glide slope system, the tidal variations will affect the glide angle. The uniform theory of diffraction is used in the analysis and calculations are made for five tidal levels from high to low tide. The results of the simulations indicate that a glide path angle exists which is least sensitive to the tidal variations. Furthermore, this optimum angle provides smooth glide path structure. Author

A86-41873#
RUNWAY REQUIREMENTS IN INSTRUMENT FLIGHT TRAFFIC AT REGIONAL AIRPORTS AND COMMERCIAL LANDING AREAS [ANFORDERUNGEN AN LANDEBAHNEN FUER INSTRUMENTENFLUGBETRIEB AUF REGIONALEN VERKEHRSFLUGHAEFEN UND VERKEHRSLANDEPLAETZEN]
Ortung und Navigation (ISSN 0474-7550), vol. 27, no. 1, 1986, p. 5-28. In German. refs

Requirements pertaining to short instrument runways are studied with regard to planning criteria, lighting, and radio-electric navigation and landing aids. It is shown that instrument runways have different safety requirements from runways of large airports. The acceptance of the ICAO Annex 14 has resulted in the considerable lessening of requirements for obstacle-free surfaces, especially in the runways, the landing and takeoff surfaces, and the lateral overflight surfaces. Short instrument runways should have bright lighting at the edges, the front and end, as well as simple approach lighting. Various combinations of radio-electric landing aids are suggested. C.D.

A86-41874#
SOPHISTICATION AND SAFETY IN A SEMI-AUTOMATED AIR TRAFFIC CONTROL SYSTEM
H. VON VILLIEZ (EUROCONTROL, Maastricht, Netherlands) (Royal Institute of Navigation, Meeting, 1st, Amsterdam, Netherlands, Oct. 1985) Ortung und Navigation (ISSN 0474-7550), vol. 27, no. 1, 1986, p. 29-39.

The need for data processing techniques in air traffic control (ATC) is discussed. The basic features of a semiautomated ATC system are: (1) flight path calculation, (2) event determination, (3)

code allocation, (4) correlation flight-plan/radar target, (5) strip printing, and (6) ACT-message exchange. The use of a composite radar picture, single and multiradar tracking, a code-callsign correlation, an executive controller message, a short-term conflict alert, and a weather contour map for completing the operational goals of an ATC system is described. The reliability and safety requirements for ATC systems are examined. The four levels of system support include: maintenance, optimization, expansion, and replacement. The applications of mode S operation to secondary surveillance systems, and color displays and voice recognition techniques to ATC are proposed. I.F.

A86-42966
FLIGHTPATH RECONSTRUCTION AND SYSTEMATIC RADAR ERROR ESTIMATION FROM MULTI-RADAR RANGE-AZIMUTH MEASUREMENTS
J. J. RENES (Nationaal Lucht- en Ruimtevaartlaboratorium, Amsterdam, Netherlands), P. V.D. KRAAN (EUROCONTROL, Brussels, Belgium), and C. EYMANN (EUROCONTROL, Experimental Centre, Bretigny-sur-Orge, France) IN: Conference on Decision and Control, 24th, Fort Lauderdale, FL, December 11-13, 1985, Proceedings. Volume 2 . New York, Institute of Electrical and Electronics Engineers, Inc., 1985, p. 1282-1285. refs
(Contract EUROCONTROL-A0/12/AN/82)

The MURATREC system designed to automatically monitor a complete system of radars and process data in order to produce aircraft reference trajectories is described. The system monitors up to eight radars and produces a data collection of 500,000 position measurements. The measurements are a collection of time, range, azimuth, and height information. The effects of systematic, random, and correlated errors on the MURATREC system are analyzed. The algorithms employed by the system for spline-B approximation are examined; a fast given transformation algorithm is used to compute the B-spline coefficients of the discrete least-squares fit to the uncorrected range and azimuth of the radar plot data. The system is evaluated and it is observed that MURATREC has an attainable absolute position accuracy of about 50 meters, except for steep and fast turns. I.F.

N86-28073# Ohio Univ., Athens. Dept. of Electrical and Computer Engineering.
SITING CRITERIA FOR MICROWAVE LANDING SYSTEMS (MLS) Final Report
R. RADCLIFF and M. F. DIBENEDETTO Jun. 1986 83 p
(Contract DTRS57-83-C-00097)
(FAA/PM-86/18; OU-AEC-81-1) Avail: NTIS HC A05/MF A01

Current siting criteria for the Microwave Landing System (MLS) are described. These criteria were obtained throught flight testing, mathematical and computer modeling, and publications from other sources. A description of MLS principles and a technical description of each of the systems components are provided. General principles germane to siting, such as critical areas and propagation effects are introduced. The criteria for siting in the MLS in an ideal airport are described. Solutions to difficult siting problems such as MLS/ILS collocation, multipath and shadowing effects, and collocation with approach lighting systems are given. Author

N86-28074*# Boeing Commercial Airplane Co., Seattle, Wash.
LOCAL FLOW MANAGEMENT/PROFILE DESCENT ALGORITHM. FUEL-EFFICIENT, TIME-CONTROLLED PROFILES FOR THE NASA TSRV AIRPLANE
J. L. GROCE, K. H. IZUMI, C. H. MARKHAM, R. W. SCHWAB, and J. L. THOMPSON May 1986 126 p
(Contract NAS1-14880)
(NASA-CR-172593; NAS 1.26:172593) Avail: NTIS HC A07/MF A01 CSCL 17G

The Local Flow Management/Profile Descent (LFM/PD) algorithm designed for the NASA Transport System Research Vehicle program is described. The algorithm provides fuel-efficient altitude and airspeed profiles consistent with ATC restrictions in a time-based metering environment over a fixed ground track. The model design constraints include accommodation of both published profile descent procedures and unpublished profile descents, incorporation of fuel efficiency as a flight profile criterion, operation within the performance capabilities of the Boeing 737-100 airplane with JT8D-7 engines, and conformity to standard air traffic navigation and control procedures. Holding and path stretching capabilities are included for long delay situations. Author

N86-28930# IIT Research Inst., Annapolis, Md.
A COMPARISON OF THE EFFECTS OF TWO TRAFFIC ALERT AND COLLISION AVOIDANCE SYSTEMS (TCAS 3 AND TCAS 2) ON THE PERFORMANCE OF THE AIR TRAFFIC CONTROL RADAR BEACON SYSTEM Final Report, May 1984 - Mar. 1986
T. OGRADY, D. KATZ, and C. CORSE Apr. 1986 44 p
(Contract F19628-85-C-0071)
(DOT/FAA/PM-86/8; ECAC-CR-86-027) Avail: NTIS HC A04/MF A01

An analysis was performed to predict the effects of the Traffic Alert and Collision Avoidance System (TCAS 3) on the performance of the Air Traffic Control Radar Beacon System (ATCRBS) in the Los Angeles Basin. This was accomplished by comparing the effects of TCAS 3 and TCAS 2 operations on airborne transponder and ground-based ATCRBS interrogator performance in the same hypothetical peak Los Angeles Basin aircraft deployment. Author

N86-28931*# Analytical Mechanics Associates, Inc., Mountain View, Calif.
EVALUATION OF THE USEFULNESS OF VARIOUS SIMULATION TECHNOLOGY OPTIONS FOR TERPS ENHANCEMENT
A. V. PHATAK and J. A. SORENSEN May 1986 33 p
(Contract NAS2-11973)
(NASA-CR-177408; NAS 1.26:177408; FAA/PM-86/15; AMA-86-2-II) Avail: NTIS HC A03/MF A01 CSCL 17G

Current approved terminal instrument procedures (TERPS) do not permit the full exploitation of the helicopter's unique flying characteristics. Enhanced TERPS need to be developed for a host of non-standard landing sites and navigation aids. Precision navigation systems such as microwave landing systems (MLS) and the Global Positioning System (GPS) open the possibility of curved paths, steep glide slopes, and decelerating helicopter approaches. This study evaluated the feasibility, benefits, and liabilities of using helicopter cockpit simulators in place of flight testing to develop enhanced TERPS criteria for non-standard flight profiles and navigation equipment. Near-term (2 to 5 year) requirements for conducting simulator studies to verify that they produce suitable data comparable to that obtained from previous flight tests are discussed. The long-term (5 to 10 year) research and development requirements to provide necessary modeling for continued simulator-based testing to develop enhanced TERPS criteria are also outlined. Author

N86-28932# Ohio Univ., Athens. Dept. of Electrical and Computer Engineering.
INVESTIGATIONS FOR IMPROVING OPERATIONAL RELIABILITY AND MAINTAINABILITY OF ILS COMPONENTS. VOLUME 2: FIGURES AND ILLUSTRATIONS Final Report, Feb. 1983 - Feb. 1986
R. H. MCFARLAND, W. D. PHIPPS, L. D. BRADY, J. DENNIS, and J. D. LONGWORTH Feb. 1986 376 p
(Contract DTFA01-83-C-20025)
(FAA/PM-86/7.11-VOL-2; OU/AEC/EER-79-1-VOL-2) Avail: NTIS HC A17/MF A01

Evaluations and performance analysis of the Instrument Landing System (ILS) are presented for Dallas-Fort Worth, Tex.; Wheeling, W.V.; Bristol, Tenn.; Parkersburg, W.V.; Pontiac, Mich.; and DeKalb-Peachtree, Ga. An investigation of anomalous performance of the glide slope at Lambert-St. Louis is reported. An analysis of Instrument Landing System (ILS) Reference Datum Heights (RDH) is reported, as well as the results of an investigation of glide slope critical areas. A study into the feasibility of developing ground-based checking techniques for validating the Sideband Reference (SBR) glide slope is presented, as well as an assessment of the current standards and tolerances used to qualify

glide slope structures. In addition, a proposed methodology for mathematical model validation is discussed. Author

N86-28933*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
DESIGN CONSIDERATIONS FOR FLIGHT TEST OF A FAULT INFERRING NONLINEAR DETECTION SYSTEM ALGORITHM FOR AVIONICS SENSORS
A. K. CAGLAYAN (Charles River Analytics, Inc., Cambridge, Mass.), P. M. GODIWALA, and F. R. MORRELL Aug. 1986 11 p Presented at the Guidance, Navigation, and Control Conference, Williamsburg, Va., 18-20 Aug. 1986
(NASA-TM-88998; NAS 1.15:88998) Avail: NTIS HC A02/MF A01 CSCL 01D

The modifications to the design of a fault inferring nonlinear detection system (FINDS) algorithm to accommodate flight computer constraints and the resulting impact on the algorithm performance are summarized. An overview of the flight data-driven FINDS algorithm is presented. This is followed by a brief analysis of the effects of modifications to the algorithm on program size and execution speed. Significant improvements in estimation performance for the aircraft states and normal operating sensor biases, which have resulted from improved noise design parameters and a new steady-state wind model, are documented. The aircraft state and sensor bias estimation performances of the algorithm's extended Kalman filter are presented as a function of update frequency of the piecewise constant filter gains. The results of a new detection system strategy and failure detection performance, as a function of gain update frequency, are also presented. Author

05

AIRCRAFT DESIGN, TESTING AND PERFORMANCE

Includes aircraft simulation technology.

A86-40106*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
COMPUTER SIZING OF FIGHTER AIRCRAFT
P. G. COEN and W. E. FOSS, JR. (NASA, Langley Research Center, Hampton, VA) Journal of Aircraft (ISSN 0021-8669), vol. 23, May 1986, p. 353, 354. Previously announced in STAR as N85-16759. refs
(AIAA PAPER 85-0212)

The computer sizing technique has been applied to a number of military mission profiles. Performance data can be determined for all segments of the selected profile, which typically include takeoff, climb, cruise, loiter, reserve and landing segments. Options are available for detailed calculation of combat performance and energy-maneuverability characteristics. Configuration changes, such as external fuel tank drop and weapon expenditure, can be included in the mission. In the sizing mode, aircraft gross weight, wing loading, and thrust-to-weight ratio are varied automatically to determine which combinations meet the design mission radius. The resulting performance data can be used to create a thumbprint plot. This plot is useful in determining the configuration size that best satisfies the mission and performance requirements. The sizing mode can also be used to perform parametric studies such as sensitivity of gross weight to alternate design conditions. Author

A86-40113#
CTOL SKI JUMP - ANALYSIS, SIMULATION, AND FLIGHT TEST
J. W. CLARK, JR. and M. M. WALTERS (U.S. Navy, Naval Air Development Center, Warminster, PA) Journal of Aircraft (ISSN 0021-8669), vol. 23, May 1986, p. 382-389.

In the past several years, the ski-jump (ramp-assisted) launch concept has received considerable attention within the U.S. Navy. The specific goal was set (and achieved) to demonstrate through flight test the feasibility of, and quantify performance gains from, ski-jump launch of the T-2C, F-14A, and F/A-18A aircraft using a 100-ft ramp with variable end angles of 6 and 9 degs. The analysis, piloted simulation, performance predictions, and flight safety considerations leading to flight test, as well as a comparison of analytical predictions with flight test results for the three aircraft, are discussed. The developed analytical capability, although somewhat conservative, proved to be highly effective in preparation for, and support of, the flight test and successfully predicting the 40-60 percent reduction in takeoff distance demonstration in flight test. Author

A86-40114#
A COMPUTER-AUGMENTED PROCEDURE FOR COMMERCIAL AIRCRAFT CONFIGURATION DEVELOPMENT AND OPTIMIZATION
C. HABERLAND, W. FENSKE (Berlin, Technische Universitaet, West Germany), and J. THORBECK (Deutsche Lufthansa AG, Hamburg, West Germany) (International Council of the Aeronautical Sciences, Congress, 14th, Toulouse, France, September 9-14, 1984, Proceedings. Volume 2, p. 943-953) Journal of Aircraft (ISSN 0021-8669), vol. 23, May 1986, p. 390-397. Previously cited in issue 22, p. 3188, Accession no. A84-45031. refs

A86-40471
BEECH'S ENTERPRISING STARSHIP
G. WARWICK Flight International (ISSN 0015-3710), vol. 129, May 3, 1986, p. 18-24.

The design and development of a new corporate turboprop, the Beech Starship 1, are described. Starship 1 is an eight-to-ten seat business turboprop aimed at the lower end of the business jet market, cruising at up to 41,000 ft and 405 mph (but not simultaneously), with a still-air range of 2250 nautical miles (enough for a nonstop flight across the U.S.), and the ability to operate out of airfields too small for jets. The design features an aft-set swept wing with rudder-equipped winglets for directional control, combined with a slender foreplane - a canard configuration or tandem wing. The airframe is almost entirely composite. Fuel efficiency is claimed to at least 25 percent better than a jet of comparable size. D.H.

A86-40472
NACES - TODAY'S ULTIMATE SEAT
M. GAINES Flight International (ISSN 0015-3710), vol. 129, May 3, 1986, p. 26-29.

The Martin-Baker Mk.14 Naces (Navy Aircrew Common Ejection Seat) is described. The Naces, to be built by Martin-Baker and produced by a U.S. company to be chosen by Martin-Baker, is to be fitted to A-6E Intruders (the new-build upgraded variant), the F-14D Tomcat, the F-18 Hornet, and the T-45A Goshawk two-seat trainer. The Navy's list of criteria, besides high performance, included low acquisition cost, commonality, ease of production, extreme ease of maintenance, high reliability, low life-cycle costs, minimum program risk, a pre-planned product improvement program for future growth and integrated logistic support. Details of construction (explosive cartridge, electronic sequencer, rocket deployment of parachute, etc.) are covered. It is noted that a safe ejection will be possible from an aircraft with nose level at 130-knot airspeed and 110 feet of altitude, with the aircraft inverted. D.H.

A86-41688#
CANARD/TAIL COMPARISON FOR AN ADVANCED VARIABLE-SWEEP-WING FIGHTER
J. P. LANDFIELD and D. RAJKOVIC (Grumman Aerospace Corp., Bethpage, NY) Journal of Aircraft (ISSN 0021-8669), vol. 23, June 1986, p. 449-454. Previously cited in issue 03, p. 257, Accession no. A85-13510. refs

A86-41692#
DESIGN OF A CARBON-FIBER REINFORCED WING FOR THE ALPHA-JET MAJOR PANEL TESTS
D. ROSE, E. HENZE (Dornier GmbH, Friedrichshafen, West Germany), D. WURZEL, and H. SCHELLING (DFVLR, Stuttgart, West Germany) (Structures, Structural Dynamics, and Materials Conference, 26th, Orlando, FL, April 15-17, 1985, Technical Papers. Part 1, p. 446-453) Journal of Aircraft (ISSN 0021-8669), vol. 23, June 1986, p. 477-483. Previously cited in issue 13, p. 1848, Accession no. A85-30278.

A86-41696*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
A FORWARD-SWEPT-WING FIGHTER CONFIGURATION DESIGNED BY A TRANSONIC COMPUTATIONAL METHOD
M. J. MANN and C. E. MERCER (NASA, Langley Research Center, Hampton, VA) Journal of Aircraft (ISSN 0021-8669), vol. 23, June 1986, p. 506-512. Previously cited in issue 01, p. 10, Accession no. A86-11035. refs

A86-41710*# Old Dominion Univ., Norfolk, Va.
THE INFLUENCE OF SOURCE LOCATION ON THE STRUCTURAL-ACOUSTIC INTERACTION OF CYLINDERS
J. J. KELLY (Old Dominion University, Norfolk, VA) and C. R. FULLER (Virginia Polytechnic Institute and State University, Blackburg) (Structures, Structural Dynamics, and Materials Conference, 26th, Orlando, FL, April 15-17, 1985, Technical Papers. Part 2, p. 609-616) AIAA Journal (ISSN 0001-1452), vol. 24, June 1986, p. 955-961. Previously cited in issue 13, p. 1899, Accession no. A85-30390. refs
(Contract NAG1-390)

A86-41976#
THE CYCLO-CRANE - A HYBRID AIRSHIP CONCEPT
J. J. MORRIS (Aerolift, Inc., Tillamook, OR) Airship, Dec. 1985, p. 9-11.

The 'Cyclo-Crane' is an aerostat that incorporates aerodynamic lift and thrust elements in order to furnish heavy lift services comparable to those of the helicopter, though at lower cost. While the Cyclo-Crane demonstration vehicle carries a 2-ton slung payload, its full size version will be capable of operations with 25 tons. Standard aircraft engines are used in what may be characterized as a tip-driven rotor configuration; VTOL capabilities are available with any two of the four engines operating. Forward movement from the hovering position is achieved by altering the pitch of the rotor blade airfoils. O.C.

A86-41977#
A THEORETICAL STUDY OF DELTOID PLANFORMS OPERATING IN THE GROUND EFFECT REGION
D. SHELDON and W. PUTNAM (Aereon Corp., Princeton, NJ) Airship, Dec. 1985, p. 11-15.

A86-42704*# Garrett Turbine Engine Co., Phoenix, Ariz.
ADVANCED TECHNOLOGY PAYOFFS FOR FUTURE ROTORCRAFT, COMMUTER AIRCRAFT, CRUISE MISSILE, AND APU PROPULSION SYSTEMS
M. A. TURK and P. K. ZEINER (Garrett Turbine Engine Co., Phoenix, AZ) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 22nd, Huntsville, AL, June 16-18, 1986. 10 p. Army-supported research.
(Contract NAS3-24544)
(AIAA PAPER 86-1545)

In connection with the significant advances made regarding the performance of larger gas turbines, challenges arise concerning the improvement of small gas turbine engines in the 250 to 1000 horsepower range. In response to these challenges, the NASA/Army-sponsored Small Engine Component Technology (SECT) study was undertaken with the objective to identify the engine cycle, configuration, and component technology requirements for the substantial performance improvements desired in year-2000 small gas turbine engines. In the context of this objective, an American turbine engine company evaluated engines for four year-2000 applications, including a rotorcraft, a commuter aircraft, a supersonic cruise missile, and an auxiliary power unit (APU). Attention is given to reference missions, reference engines, reference aircraft, year-2000 technology projections, cycle studies, advanced engine selections, and a technology evaluation. G.R.

A86-42829*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
HELICOPTER ROTOR AND ENGINE SIZING FOR PRELIMINARY PERFORMANCE ESTIMATION
P. D. TALBOT, J. V. BOWLES, and H. C. LEE (NASA, Ames Research Center, Moffett Field, CA) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 22nd, Huntsville, AL, June 16-18, 1986. 17 p. refs
(AIAA PAPER 86-1756)

Methods are presented for estimating some of the more fundamental design variables of single-rotor helicopters (tip speed, blade area, disk loading, and installed power) based on design requirements (speed, weight, fuselage drag, and design hover ceiling). The well-known constraints of advancing-blade compressibility and retreating-blade stall are incorporated into the estimation process, based on an empirical interpretation of rotor performance data from large-scale wind-tunnel tests. Engine performance data are presented and correlated with a simple model usable for preliminary design. When approximate results are required quickly, these methods may be more convenient to use and provide more insight than large digital computer programs.
Author

A86-43002
APPLICATION OF SYSTEM IDENTIFICATION TO AIRCRAFT FLIGHT TEST DATA PROCESSING
L. C. ANDERSON and J. H. VINCENT (Systems Control Technology, Inc., Palo Alto, CA) IN: Conference on Decision and Control, 24th, Fort Lauderdale, FL, December 11-13, 1985, Proceedings. Volume 3 . New York, Institute of Electrical and Electronics Engineers, Inc., 1985, p. 1929-1931.

A parameter identification technique for developing an aerodynamic model of the AV-8B aircraft with flight test data is described. The methods utilized to generate the model parameters, which include cubic spline functions, an equation error technique, and equation error/regression methods, are discussed. The test data was collected from flight maneuver tests involving 23 maneuvers of 30 sec durations. The determination of the model structure is examined. A principal components regression algorithm is applied to the identification of the model parameters. Nonlinear aerodynamic coefficients for yawing moment due to sideslip, yawing moment versus sideslip, rolling moment due to aileron, and rolling moment due to roll rate are identified. The flight test identified model is compared to wind tunnel data and good correlation is detected. I.F.

A86-43380
INFLUENCE OF STRUCTURAL CHANGES ON THE FUEL-CONSUMPTION EFFICIENCY OF A TRANSPORT AIRCRAFT [VLIIANIE KONSTRUKTIVNYKH IZMENENII NA TOPLIVNUIU EFFEKTIVNOST' TRANSPORTNOGO SAMOLETA]
V. P. GOGOLIN Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 1, 1986, p. 19-22. In Russian.

Formulas are obtained for determining the final change in the fuel mass on an aircraft as changes in the masses of the aircraft components are carried out. The fuel-mass and aircraft-mass criteria are compared in terms of the significance of drag changes. B.J.

A86-43385
THEORY OF THE MOTION OF PROPELLER BLADES FOR LARGE DISPLACEMENTS [TEORIIA DVIZHENIIA LOPASTEI NESUSHCHEGO VINTA PRI BOL'SHIKH PEREMESHCHENIIAKH]
V. A. PAVLOV and S. A. MIKHAILOV Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 1, 1986, p. 39-42. In Russian. refs

A method is proposed for deriving the equations of motion of propeller blades in a flow for large displacements. The mathematical model of a blade being deformed by an arbitrary load is constructed on the basis of spatial-straight-line theory. The external-load components are determined from the deformation grid. B.J.

A86-43389
LAYOUT OF ELECTRICAL EQUIPMENT ON AN AIRCRAFT WITH ALLOWANCE FOR EQUIPMENT SIZE CONSTRAINTS IN THE FRAMEWORK OF COMPUTER-AIDED DESIGN [KOMPONOVKA I RAZMESHCHENIIE ELEKTROKONSTRUKTSII NA SAMOLETE S UCHETOM OGRANICHENII NA IKH OBE'MY PRI AVTOMATIZIROVANNOM PROEKTIROVANII]
V. S. TERESHCHUK and V. P. GORIACHKIN Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 1, 1986, p. 57-61. In Russian. refs

Dynamic programming is used to solve the layout problem for the secondary power supply system on an aircraft, with allowance for size constraints. The method used can serve as the basis for the program module in a system for the computer-aided design of aircraft electrical equipment. B.J.

N86-28075*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
LOADS CALIBRATIONS OF STRAIN GAGE BRIDGES ON THE DAST PROJECT AEROELASTIC RESEARCH WING (ARW-2)
C. V. ECKSTROM Mar. 1986 118 p
(NASA-TM-87677; NAS 1.15:87677) Avail: NTIS HC A06/MF A01 CSCL 01C

Results from and details of the procedure used to calibrate strain gage bridges for measurements of wing structural loads, shear (V), bending moment (M), and torque (T), at three semispan stations on both the left and right semispans of the ARW-2 wing are presented. The ARW-2 wing has a reference area of 35 square feet, a span of 19 feet, an aspect ratio of 10.3, a midchord line sweepback angle of 25 degrees, and a taper ratio of 0.4. The ARW-2 wing was fabricated using aluminum spars and ribs covered with a fiberglass/honeycomb sandwich skin material. All strain gage bridges are mounted along with an estimate of their accuracy by means of a comparison of computed loads versus actual loads for three simulated flight conditions. Author

N86-28076*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
NASTRAN/FLEXSTAB PROCEDURE FOR STATIC AEROELASTIC ANALYSIS
L. S. SCHUSTER Sep. 1984 21 p
(NASA-TM-84897; NAS 1.15:84897) Avail: NTIS HC A02/MF A01 CSCL 01C

Presented is a procedure for using the FLEXSTAB External Structural Influence Coefficients (ESIC) computer program to produce the structural data necessary for the FLEXSTAB Stability Derivatives and Static Stability (SD&SS) program. The SD&SS program computes trim state, stability derivatives, and pressure and deflection data for a flexible airplane having a plane of symmetry. The procedure used a NASTRAN finite-element structural model as the source of structural data in the form of flexibility matrices. Selection of a set of degrees of freedom, definition of structural nodes and panels, reordering and reformatting of the flexibility matrix, and redistribution of existing point mass data are among the topics discussed. Also discussed are boundary conditions and the NASTRAN substructuring technique. Author

N86-28077*# McDonnell-Douglas Corp., Long Beach, Calif.
EVALUATION OF LAMINAR FLOW CONTROL SYSTEMS CONCEPTS FOR SUBSONIC COMMERCIAL TRANSPORT AIRCRAFT Final Report
W. E. PEARCE Jun. 1983 504 p
(Contract NAS1-14632)
(NASA-CR-159251; NAS 1.26:159251; ACEE-01-FR-3132) Avail: NTIS HC A22/MF A01 CSCL 01C

An evaluation was made of laminar flow control (LFC) system concepts for subsonic commercial transport aircraft. Configuration design studies, performance analyses, fabrication development, structural testing, wind tunnel testing, and contamination-avoidance techniques were included. As a result of trade studies, a configuration with LFC on the upper wing surface only, utilizing an electron beam-perforated suction surface, and employing a retractable high-lift shield for contamination avoidance, was selected as the most practical LFC system. The LFC aircraft was then compared with an advanced turbulent aircraft designed for the same mission. This comparison indicated significant fuel savings and reduced direct operating cost benefits would result from using LFC. Author

N86-28078*# National Aeronautics and Space Administration. Dryden (Hugh L.) Flight Research Center, Edwards, Calif.
APPLICATION OF PARAMETER ESTIMATION TO HIGHLY UNSTABLE AIRCRAFT
R. E. MAINE and J. E. MURRAY Aug. 1986 14 p Proposed for presentation at the AIAA Atmospheric Flight Mechanics Conference, Williamsburg, Va., 18-20 Aug. 1986
(NASA-TM-88266; H-1365; NAS 1.15:88266; AIAA-86-2020-CP)
Avail: NTIS HC A02/MF A01 CSCL 01C

The application of parameter estimation to highly unstable aircraft is discussed. Included are a discussion of the problems in applying the output error method to such aircraft and demonstrates that the filter error method eliminates these problems. The paper shows that the maximum likelihood estimator with no process noise does not reduce to the output error method when the system is unstable. It also proposes and demonstrates an ad hoc method that is similar in form to the filter error method, but applicable to nonlinear problems. Flight data from the X-29 forward-swept-wing demonstrator is used to illustrate the problems and methods discussed. Author

N86-28079*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
EFFECTS OF BLADE-TO-BLADE DISSIMILARITIES ON ROTOR-BODY LEAD-LAG DYNAMICS
M. J. MCNULTY Mar. 1986 31 p
(Contract K-1053)
(NASA-TM-86828; A-85393; NAS 1.15:86828; USAAVSCOM-TM-86-A-3) Avail: NTIS HC A03/MF A01 CSCL 01C

Small blade-to-blade property differences are investigated to determine their effects on the behavior of a simple rotor-body system. An analytical approach is used which emphasizes the significance of these effects from the experimental point of view. It is found that the primary effect of blade-to-blade dissimilarities is the appearance of additional peaks in the frequency spectrum which are separated from the convention response modes by multiples of the rotor speed. These additional responses are potential experimental problems because when they occur near a mode of interest they act as contaminant frequencies which can make damping measurements difficult. The effects of increased rotor-body coupling and a rotor shaft degree of freedom act to improve the situation by altering the frequency separation of the modes. Author

N86-28080# Aeronautical Research Labs., Melbourne (Australia).
MIRAGE A3-002 STRAIN RESPONSES TO GROUND CALIBRATION LOADINGS BETWEEN 1978 AND 1985
M. G. J. HIGGS Dec. 1985 116 p
(AD-A165846; ARL-STRUC-TM-425) Avail: NTIS HC A06/MF A01 CSCL 01C

Prior to flight trials in 1978, a calibration of strain gauges fitted to Mirage A3-002 was carried out by measuring responses to ground loads applied at several locations on the Mirage wing. Since 1978, further ground calibrations have been made on the same aircraft. The loading procedure used was similar to that for earlier ground calibrations of other Mirage aircraft. This technical memorandum provides a record of the output of strain gauges fitted to A3-002, and identifies some trends in these outputs. For some gauges, data is given for a seven-year period. Two loading cases are presented: (1) loading at the main external store attachment point, and (2) loading at the Sidewinder attachment point. The discussion is restricted to strain gauges fitted to wings and to fuselage frame 26. In general, consistent results were obtained over the measurement period. GRA

N86-28081# Aeronautical Research Inst. of Sweden, Stockholm. Structures Dept.
PROBABILISTIC DAMAGE TOLERANCE ANALYSIS OF AIRCRAFT STRUCTURES
B. PALMBERG, A. F. BLOM, and S. EGGWERTZ Nov. 1985 136 p Submitted for publication
(Contract STU-84-4563)
(FFA-TN-1985-68; ESA-86-97055) Avail: NTIS HC A07/MF A01

The state of the art in probabilistic damage tolerance analysis was reviewed. A probabilistic model for fatigue life prediction based on existing models for probabilistic characterization of initial flaw sizes, fatigue crack growth and failure was developed. The effect of periodic inspections is taken into account. A numerical example which shows practical difficulties involved in the analysis, but also the advantage of inspections from a safety point of view is included. ESA

N86-28082# Societe Nationale Industrielle Aerospatiale, Toulouse (France). Div. Avions.
THE DESIGN OF COMPOSITE STRUCTURES [LA CONCEPTION DES STRUCTURES COMPOSITES]
G. HELLARD 13 Feb. 1985 22 p In FRENCH Presented at 1st Bonded Aircraft Struct. Tech. Appl. and Repairs Tech. Congr., Seeheim, West Ger., 23 Jan. 1985
(SNIAS-861-111-103; GCO/GH/CL-442.026/85; ESA-86-97140) Avail: NTIS HC A02/MF A01

The principles of aircraft element design using composite materials are outlined. Glass carbon and Kevlar composites are discussed. Sandwich and monolothic structures are described and application criteria are detailed. Drawings detailing the composite elements of the A-310 to A-330 and ATR-42 aircrafts and the particular design of those elements are presented. ESA

N86-28083# Societe Nationale Industrielle Aerospatiale, Toulouse (France).
THE SIGMA CADCAM SOFTWARE [SIGMA, LOGICIEL DE CFAO]
R. GANDOU and P. JUBERT 16 Dec. 1985 14 p In FRENCH Presented at Congr. on Le Calcul Demain, Grenoble, France, 6 Dec. 1985 Submitted for publication
(SNIAS-861-111-110; ESA-86-97146) Avail: NTIS HC A02/MF A01

A software system for designing and handling complex three-dimensional shapes based on a polynomial representation of curves and surfaces derived from Bezier-Berstein functions is described. Applications include aviation (designing wings, forward fuselages, wing-fuselage joints, engine pods and pylons) ship building (designing hulls) the automobile industry (bodywork), and all industries for which the design of shapes raises complex problems, requiring considerable interactivity, extremely good computation accuracy, and manipulation of surfaces by blending, cutting out, etc. The man machine dialog; the creation of shapes; the exploitation of shapes; and manufacture are discussed. ESA

N86-28084# Societe Nationale Industrielle Aerospatiale, Marignane (France). Structures Dept.
COMPUTING CODES FOR DEVELOPMENT OF HELICOPTER CRASHWORTHY STRUCTURES AND TEST SUBSTANTIATION
J. MENS and J. C. BIANCHINI (Engineering System International, Rungis, France) 1986 14 p Presented at AHS/NAI Intern. Seminar, Nanjing, China, 6-8 Jan. 1985 Sponsored by Direction des Recherches Etudes et Techniques
(SNIAS-861-210-106; ESA-86-97154) Avail: NTIS HC A02/MF A01

Computing tools used in designing crashworthy helicopters are described. The dynamic behavior of components during impact on ground is computed by the KRASH program. The buckling load of panels stiffened by angles, Z-sections, or honeycomb panels, is computed by a purely analytic computer code. The complete buckling and post-buckling behavior of the structure components can be successfully described by the PAM CRASH computer program system, taking account of specific support and contact conditions as well as possible interaction between fluid and structure; the programs use the finite element method in large deformations and the nonlinear behavior of materials. In static or slightly dynamic analyses, an implicit integration scheme is used. For higher velocity impact, an explicit scheme is more effective. Hybridization of the analytical model within an implicit numerical code gives results which are very comparable with a purely numerical calculation, but at lower cost. ESA

N86-28935*# Massachusetts Inst. of Tech., Cambridge.
FORMAL OPTIMIZATION OF HOVERING PERFORMANCE USING FREE WAKE LIFTING SURFACE THEORY
S. Y. CHUNG Feb. 1986 260 p
(Contract NAG2-275)
(NASA-CR-177103; NAS 1.26:177103) Avail: NTIS HC A12/MF A01 CSCL 01C

Free wake techniques for performance prediction and optimization of hovering rotor are discussed. The influence functions due to vortex ring, vortex cylinder, and source or vortex sheets are presented. The vortex core sizes of rotor wake vortices are calculated and their importance is discussed. Lifting body theory for finite thickness body is developed for pressure calculation, and hence performance prediction of hovering rotors. Numerical optimization technique based on free wake lifting line theory is presented and discussed. It is demonstrated that formal optimization can be used with the implicit and nonlinear objective or cost function such as the performance of hovering rotors as used in this report. Author

N86-28936*# California Polytechnic State Univ., San Luis Obispo. Dept. of Aeronatuical Engineering.
DEVELOPMENT OF FLIGHT TESTING TECHNIQUES Final Report, 31 Oct. 1979 - 31 Oct. 1984
D. R. SANDLIN Oct. 1984 9 p
(Contract NCC4-1)
(NASA-CR-176996; NAS 1.26:176996) Avail: NTIS HC A02/MF A01 CSCL 01C

A list of students involved in research on flight analysis and development is given along with abstracts of their work. The following is a listing of the titles of each work: Longitudinal stability and control derivatives obtained from flight data of a PA-30 aircraft; Aerodynamic drag reduction tests on a box shaped vehicle; A microprocessor based anti-aliasing filter for a PCM system; Flutter prediction of a wing with active aileron control; Comparison of theoretical and flight measured local flow aerodynamics for a low aspect ratio fin; In flight thrust determination on a real time basis; A comparison of computer generated lift and drag polars for a Wortmann airfoil to flight and wind tunnel results; and Deep stall flight testing of the NASA SGS 1-36. E.R.

N86-28937*# California Polytechnic State Univ., San Luis Obispo. Dept. of Aeronatuical Engineering.
IN-FLIGHT THRUST DETERMINATION ON A REAL-TIME BASIS Final Report
R. J. RAY, T. CARPENTER, and T. SANDLIN Apr. 1984 39 p
(Contract NCC4-1)
(NASA-CR-176997; NAS 1.26:176997) Avail: NTIS HC A03/MF A01 CSCL 01C

A real time computer program was implemented on a F-15 jet fighter to monitor in-flight engine performance of a Digital Electronic Engine Controlled (DEES) F-100 engine. The application of two gas generator methods to calculate in-flight thrust real time is described. A comparison was made between the actual results and those predicted by an engine model simulation. The percent difference between the two methods was compared to the predicted uncertainty based on instrumentation and model uncertainty and agreed closely with the results found during altitude facility testing. Data was obtained from acceleration runs of various altitudes at maximum power settings with and without afterburner. Real time in-flight thrust measurement was a major advancement to flight test productivity and was accomplished with no loss in accuracy over previous post flight methods. Author

N86-28939*# Boeing Commercial Airplane Co., Seattle, Wash.
DESIGN REQUIREMENTS AND DEVELOPMENT OF AN AIRBORNE DESCENT PATH DEFINITION ALGORITHM FOR TIME NAVIGATION Final Report
K. H. IZUMI, J. L. THOMPSON, J. L. GROCE, and R. W. SCHWAB May 1986 67 p
(Contract NAS1-16300)
(NASA-CR-178037; NAS 1.26:178037) Avail: NTIS HC A04/MF A01 CSCL 17G

The design requirements for a 4D path definition algorithm are described. These requirements were developed for the NASA ATOPS as an extension of the Local Flow Management/Profile Descent algorithm. They specify the processing flow, functional and data architectures, and system input requirements, and recommended the addition of a broad path revision (reinitialization) function capability. The document also summarizes algorithm design enhancements and the implementation status of the algorithm on an in-house PDP-11/70 computer. Finally, the requirements for the pilot-computer interfaces, the lateral path processor, and guidance and steering function are described. Author

N86-28940*# Boeing Commercial Airplane Co., Seattle, Wash.
AN INVESTIGATION OF TNAV EQUIPPED AIRCRAFT IN A SIMULATED EN ROUTE METERING ENVIRONMENT Final Report
J. L. GROCE, K. H. IZUMI, C. H. MARKHAM, R. W. SCHWAB, and J. A. TAYLOR 5 May 1986 98 p
(Contract NAS1-16300)
(NASA-CR-178031; NAS 1.26:178031; D6-52321) Avail: NTIS HC A05/MF A01 CSCL 01C

This document presents the results of an effort to estimate how often a TNAV (Time Navigation) equipped aircraft could be given a TNAV clearance in the En Route Metering (ERM) system as a function of the percentage of arriving traffic which is TNAV equipped. A fast-time simulation of Denver Stapleton international arrival traffic in the Denver Air Route Traffic Control Center route structure, including en route metering operations, was used to develop data on estimated conflicts, clearance communications and fuel usage for traffic mixes of 25, 50, 75 and 100% TNAV equipped. This study supports an overall effort by NASA to assess the benefits and required technology for using TNAV-equipped aircraft in the ERM environment. Author

N86-28941# Societe Nationale des Poudres et Explosifs, Vert-Le-Petit (France).
NEW TRANSPARENT SOLID MATERIAL FOR HELICOPTER WINDSHIELDS Final Report [NOUVEAU MATERIAU MASSIF TRANSPARENT POUR VITRAGE D'HELICOPTERE]
J. PATTEIN 22 Apr. 1985 37 p In FRENCH
(Contract DRET-83-129)
(SNPE-NT-37/85/CRB/NP; ESA-86-97197) Avail: NTIS HC A03/MF A01

Polyurethanes and acrylic-urethane copolymers were studied by experimental casting of large plates. Better properties are obtained by comparison to currently used acrylics, including shock resistance, crazing resistance, thermal behavior, and surface properties. Large problems remain due to mold extraction difficulties, resulting in poor surface appearance. ESA

N86-28942# Office National d'Etudes et de Recherches Aerospatiales, Paris (France). Dir. Scientifique de la Resistance des Structures.
AEROELASTIC TESTS OF OA 206 AND OA 207 PROFILES [ESSAIS AEROELASTIQUES DES PROFILES OA 206 ET OA 207]
B. PELEAU May 1985 73 p In FRENCH
(Contract STPA-83-95-013)
(ONERA-RT-22/1841-RY-310-R; ONERA-RT-22/1841-RY-311-G; ESA-86-97201) Avail: NTIS HC A04/MF A01

Helicopter rotor wings were tested in a wind tunnel in order to verify a semiempirical unsteady separation model. Static tests and small amplitude sine vibration tests were carried out. The OA 207 profile was also studied using large amplitude oscillations. The detailed numerical results are presented. The small amplitude data are used to establish the model while the large amplitude data are useful for its validation. ESA

N86-28943# National Aerospace Lab., Amsterdam (Netherlands). Structures and Materials Div.
AN INTRODUCTORY COURSE ON AIRCRAFT LOADING
J. B. DEJONGE 1984 105 p Presented at Summer Course, Bandung, Indonesia, 1984
(NLR-MP-84090-U; B8660423; ESA-86-97506) Avail: NTIS HC A06/MF A01

Flight loads on aircraft; the effects of flexibility; and loads in continuous turbulence are introduced. Loads in steady horizontal flight; maneuver loads; gust loads; ground loads; landing loads; taxiing and handling loads; pressurization loads; and acoustic loads are discussed. ESA

06

AIRCRAFT INSTRUMENTATION

Includes cockpit and cabin display devices; and flight instruments.

A86-40854* National Aeronautics and Space Administration. Wallops Flight Center, Wallops Island, Va.
ELIMINATION OF DIRECTIONAL WAVE SPECTRUM CONTAMINATION FROM NOISE IN ELEVATION MEASUREMENTS
E. J. WALSH (NASA, Wallops Flight Center, Wallops Island, VA; NOAA, Propagation Laboratory, Boulder, CO), D. W. HANCOCK, III, D. E. HINES (NASA, Wallops Flight Center, Wallops Island, VA), R. N. SWIFT, and J. F. SCOTT (EG&G Washington Analytical Services Center, Inc., Pocomoke City, MD) IEEE Journal of Oceanic Engineering (ISSN 0364-9059), vol. OE-10, Oct. 1985, p. 376-381. refs

The Surface Contour Radar (SCR) is a 36-GHz computer-controlled airborne radar which generates a false-color-coded elevation map of the sea surface below the aircraft in real time, and can routinely produce ocean directional wave spectra with post-flight data processing which have much

higher angular resolution than pitch-and-roll buoys. The SCR range measurements are not error-free and the resulting errors in the elevations corrupt the directional wave spectrum. This paper presents a technique for eliminating that contamination. Author

N86-28944# RJO Enterprises, Inc., Lanham, Md.
AIRCRAFT AVIONICS SUITABLE FOR ADVANCED APPROACH APPLICATIONS. VOLUME 1: AIRCRAFT FLEET EQUIPAGE
S. KOWALSKI and T. H. CROSWELL Jul. 1986 111 p
(Contract DTFA01-84-Y-01051)
(DOT/FAA/PM-86/25,1) Avail: NTIS HC A06/MF A01

This report catalogs the aircraft avionics suitable for advanced approach applications. The configuration and model numbers of avionics used in navigation and approaches for landing are provided for 79 different types of aircraft. Aircraft are grouped into five user communities which cover Major Air Carriers, Regional Air Carriers, Executive Jets, General Aviation Aircraft, and IFR Helicopters. Avionics evaluation includes VOR NAVs, ADFs, DMEs, RNAVs, AFCS, weather radar and the associated display instruments. These navigation systems are the most popular units for navigation and landing in todays aircraft. ILS glideslope receivers, marker beacon systems, navigation management systems, vertical navigation systems, and long range navigation systems are not covered. Author

N86-28945*# University of Southern Colorado, Pueblo. School of Applied Science and Engineering Technology.
INVESTIGATION OF AN ADVANCED FAULT TOLERANT INTEGRATED AVIONICS SYSTEM Final Technical Report, Nov. 1983 - Mar. 1986
W. R. DUNN, D. COTTRELL, J. FLANDERS, A. JAVORNIK, and M. RUSOVICK Mar. 1986 76 p
(Contract NCC2-277)
(NASA-CR-176980; NAS 1.26:176980) Avail: NTIS HC A05/MF A01 CSCL 01D

Presented is an advanced, fault-tolerant multiprocessor avionics architecture as could be employed in an advanced rotorcraft such as LHX. The processor structure is designed to interface with existing digital avionics systems and concepts including the Army Digital Avionics System (ADAS) cockpit/display system, navaid and communications suites, integrated sensing suite, and the Advanced Digital Optical Control System (ADOCS). The report defines mission, maintenance and safety-of-flight reliability goals as might be expected for an operational LHX aircraft. Based on use of a modular, compact (16-bit) microprocessor card family, results of a preliminary study examining simplex, dual and standby-sparing architectures is presented. Given the stated constraints, it is shown that the dual architecture is best suited to meet reliability goals with minimum hardware and software overhead. The report presents hardware and software design considerations for realizing the architecture including redundancy management requirements and techniques as well as verification and validation needs and methods. Author

N86-29080# Joint Publications Research Service, Arlington, Va.
AERITALIA: AVIONICS, OPTOELECTRONICS RESEARCH, ATR 42
A. MONDINI *In its* Europe Report: Science and Technology (JPRS-EST-86-008) p 2-5 18 Jun. 1986 Transl. into ENGLISH from Science Duemila (Rome, Italy), no. 4, Apr. 1986 p 30-33
Avail: NTIS HC A06/MF A01

The avionic systems on aircraft being designed by Aeritalia are discussed. The installation of the first European optical fiber system on board a G-22 aircraft of the Italian Air Force is planned. This experiment will be the start of a new phase of study for the installation of a complete optical fiber system on board an advanced aircraft. The Automatic Test Equipment (ATE) is explained. Also discussed is the telematic laser targeting equipment for armored vehicles. Propfan technology is examined. B.G.

07

AIRCRAFT PROPULSION AND POWER

Includes prime propulsion systems and systems components, e.g., gas turbine engines and compressors; and on-board auxiliary power plants for aircraft.

A86-40119#
A NEW APPROACH TO DURABILITY PREDICTION FOR FUEL TANK SKINS
M. A. FERMAN, W. H. UNGER, C. R. SAFF (McDonnell Aircraft Co., St. Louis, MO), and M. D. RICHARDSON (USAF, Wright Aeronautical Laboratories, Wright-Patterson AFB, OH) (Structures, Structural Dynamics, and Materials Conference, 26th, Orlando, FL, April 15-17, 1985, Technical Papers. Part 2, p. 102-109) Journal of Aircraft (ISSN 0021-8669), vol. 23, May 1986, p. 431-437. Previously cited in issue 13, p. 1850, Accession no. A85-30331. refs

A86-40133
A NEW GENERATION T56 TURBOPROP ENGINE
W. L. MCINTIRE (General Motors Corp., Allison Gas Turbine Div., Indianapolis, IN) International Journal of Turbo and Jet-Engines (ISSN 0334-0082), vol. 2, no. 3, 1985, p. 189-197.

The T56 Series IV turboprop development program attempts to improve output power and specific fuel consumption (SFC) while retaining the T56 family's proven design features. Toward these ends, compressor blading efficiency has been increased by 5.6 percent, turbine efficiency has been increased by 2.0 percent, and turbine inlet temperature has been increased by 180 F, yielding a 10.5-percent reduction in SFC and a power output growth of 21 percent over the basic T56 design. Engines of Series IV type will be available in late 1986 for use in U.S. Navy E-2 aircraft, with follow-on application to U.S. Air Force C-130 and Navy P-3 aircraft. The engine will also be applicable to naval vessel propulsion. O.C.

A86-40726
TURBOMACHINERY PERFORMANCE DETERIORATION; PROCEEDINGS OF THE FOURTH JOINT FLUID MECHANICS, PLASMA DYNAMICS, AND LASERS CONFERENCE, ATLANTA, GA, MAY 12-14, 1986
W. TABAKOFF, ED. (Cincinnati, University, OH) Conference sponsored by AIAA and ASME. New York, American Society of Mechanical Engineers (Fluids Engineering Symposia Series. Volume FED-37), 1986, 162 p. For individual items see A86-40727 to A86-40740.

Various papers on engine performance deterioration and retention, turbines and compressor erosion, turbomachinery permanent and temporary performance losses, and gas and steam turbines performance deterioration are presented. The topics discussed include: compressor erosion and performance deterioration, response of an operational turbofan engine to a simulated nuclear blast, design features for performance retention in the CFM65 engine, deterioration factors in Rolls-Royce RB211 in-service performance, effect of particle characteristics on trajectories and blade impact pattern, and prediction of fouled compressor performance using stage stacking techniques. Also covered are: dilute gas-particle flow in a centrifugal compressor impeller, particle trajectories in full 3D flow field of turbomachinery, single-stage axial flow compressor performance deterioration, response of axial compressor to distorted inlet flow, clearance effects on heat transfer at the tips of plain and grooved turbine airfoils, effects of water ingestion into jet engine compressors, and liquid drop impact against a solid surface. C.D.

A86-40727#
COMPRESSOR EROSION AND PERFORMANCE DETERIORATION
W. TABAKOFF (Cincinnati, University, OH) IN: Turbomachinery performance deterioration; Proceedings of the Fourth Joint Fluid Mechanics, Plasma Dynamics, and Lasers Conference, Atlanta, GA, May 12-14, 1986 . New York, American Society of Mechanical Engineers, 1986, p. 1-13. refs
(Contract DAAG29-82-K-0029)

Aircraft engines operating in areas where the atmosphere is polluted by small solid particles are typical examples of jet engines operating under hostile atmospheric environment. The particles may be different kinds of sand, volcanic ashes or others. Under these conditions, the gas and particles experience different degrees of turning as they flow through the engine. This is mainly due to the difference in their inertia. This paper presents the results of an investigation of the solid particle dynamics through a helicopter engine with inlet particle separator. The particle trajectories are computed in the inlet separator which is characterized by considerable hub and tip contouring and radial variation in the swirling vane shape. The nonseparated particle trajectories are determined through the deswirling vanes and the five stage axial flow compressor. The results from this study includes the frequency of particle impacts and the erosion distribution on the blade surfaces. Author

A86-40728#
RESPONSE OF AN OPERATIONAL TURBOFAN ENGINE TO A SIMULATED NUCLEAR BLAST
M. G. DUNN, C. PADOVA (Calspan Advanced Technology Center, Buffalo, NY), and R. M. ADAMS (DNA, Alexandria, VA) IN: Turbomachinery performance deterioration; Proceedings of the Fourth Joint Fluid Mechanics, Plasma Dynamics, and Lasers Conference, Atlanta, GA, May 12-14, 1986 . New York, American Society of Mechanical Engineers, 1986, p. 15-24. refs
(Contract DNA001-79-C-0155; DNA001-81-C-0058)

This paper describes the results of a measurement program designed to determine the transient response of an air-breathing propulsion system to simulated nuclear blast waves. A Ludwieg-tube facility, incorporating a driver technique consisting of an activating chamber and a nonfrangible diaphragm, was used to create the required shock waves. Detailed measurements were performed at incident shock overpressures of approximately 6.9, 10.3, 13.8 and 17.2 kPa (1.0, 1.5, 2.0 and 2.5 psi). For each of these overpressures, data were obtained for engine speeds of 0, 80, 90 and 100 percent of maximum speed. Typical results are presented for distortion patterns at the fan face for both an extended bellmouth and a S-shaped inlet at either 0 or 20 deg yaw angle. Author

A86-40729#
DESIGN FEATURES FOR PERFORMANCE RETENTION IN THE CFM56 ENGINE
R. C. PETERSON (General Electric Co., Aircraft Engine Business Group, Cincinnati, OH) IN: Turbomachinery performance deterioration; Proceedings of the Fourth Joint Fluid Mechanics, Plasma Dynamics, and Lasers Conference, Atlanta, GA, May 12-14, 1986 . New York, American Society of Mechanical Engineers, 1986, p. 33-39.

The objective of the program described in this paper was to identify, substantiate and introduce additional design features into the CFM56 engine which will provide longer on-wing engine performance and stability margin retention considering dust ingestion effects. The initial CFM56 engine design already included many features to provide excellent retention characteristics considering other operational effects. This paper describes the initial CFM56 engine performance characteristics in DC-8 service and the design changes made to the engine which resulted in a major improvement in these characteristics. Also described is the extensive ground engine ingestion test program conducted to duplicate the initial DC-8 service results and then to evaluate and substantiate the benefits of the design improvements. Author

A86-40730#
FACTORS RELATING TO DETERIORATION BASED ON ROLLS-ROYCE RB 211 IN SERVICE PERFORMANCE
J. K. CROSBY (Rolls-Royce, Ltd., Derby, England) IN: Turbomachinery performance deterioration; Proceedings of the Fourth Joint Fluid Mechanics, Plasma Dynamics, and Lasers Conference, Atlanta, GA, May 12-14, 1986 . New York, American Society of Mechanical Engineers, 1986, p. 41-47.

The in-service performance deterioration of an aircraft jet engine is discussed. Some aspects of the economics of deterioration are addressed, stressing the effect of deterioration on excess fuel costs. Design principles to minimize deterioration are discussed, specifying methods to handle dirt deposits, erosion, and rubbing contact. Design techniques for handling the problems caused by temperature differences are considered, especially those that affect seals. Methods of detecting deterioration are discussed, including quantifying the penalty in terms of overall engine/aircraft performance loss, usually in terms of increased fuel consumption, and identifying the components responsible for the penalty. C.D.

A86-40731#
EFFECT OF PARTICLE CHARACTERISTICS ON TRAJECTORIES AND BLADE IMPACT PATTERNS
A. HAMED (Cincinnati, University, OH) IN: Turbomachinery performance deterioration; Proceedings of the Fourth Joint Fluid Mechanics, Plasma Dynamics, and Lasers Conference, Atlanta, GA, May 12-14, 1986 . New York, American Society of Mechanical Engineers, 1986, p. 49-58. DOE-supported research. refs
(Contract DAAG29-82-K-0029)

This work presents the results of a detailed study of the effect of particle characteristics on the particle dynamics and on the resulting pattern of blade impacts in a two stage axial flow gas turbine operating with particle laden flows. The particle dynamics computations combine particle-blade impact characteristics, as determined from a three dimensional trajectory analysis with particle rebound characteristics, which are obtained from experimental data. The results show the pattern and blade impacts in all stationary and rotating blade rows for fly ash and for sand particles. The results demonstrate that drastically different patterns of particle blade impacts are associated with different particles. Author

A86-40732#
PREDICTION OF FOULED COMPRESSOR PERFORMANCE USING STAGE STACKING TECHNIQUES
H. I. H. SARAVANAMUTTO (Carleton University, Ottawa, Canada) and A. N. LAKSHMINARASIMHA IN: Turbomachinery performance deterioration; Proceedings of the Fourth Joint Fluid Mechanics, Plasma Dynamics, and Lasers Conference, Atlanta, GA, May 12-14, 1986 . New York, American Society of Mechanical Engineers, 1986, p. 59-66. NSERC-supported research. refs

The importance of compressor fouling effects on gas turbine operation is summarised. An axial multi-stage compressor performance prediction model for the simulation of the effects of fouling is described, and results for various types of fouling simulated for an actual compressor configuration are presented. Author

A86-40735#
STUDY OF SINGLE STAGE AXIAL FLOW COMPRESSOR PERFORMANCE DETERIORATION
W. TABAKOFF (Cincinnati, University, OH) IN: Turbomachinery performance deterioration; Proceedings of the Fourth Joint Fluid Mechanics, Plasma Dynamics, and Lasers Conference, Atlanta, GA, May 12-14, 1986 . New York, American Society of Mechanical Engineers, 1986, p. 95-100.
(Contract DAAG29-82-K-0029)

An investigation carried out on a single stage axial flow compressor to study the effect on performance deterioration of erosion due to operation in an atmosphere polluted by solid particles is reported. The experimental unit is described, including the drive unit, the test compressor, the particle feeding mechanism, and the instrumentation. The test procedure is summarized, and the results are analyzed. It is found that erosion damage can lead

to significant reduction in engine efficiency and performance. The performance reduction is due mainly to changes in the blade leading and trailing edges, tip leakages, surface roughness, and pressure distribution. The data obtained from trajectory calculations are in very good agreement with the experimental findings. C.D.

A86-40736#
EXPERIMENTAL AND NUMERICAL STUDY OF THE RESPONSE OF AN AXIAL COMPRESSOR TO DISTORTED INLET FLOW
G. BILLET, J. HUARD, P. CHEVALIER, and P. LAVAL (ONERA, Chatillon-sous-Bagneux, France) IN: Turbomachinery performance deterioration; Proceedings of the Fourth Joint Fluid Mechanics, Plasma Dynamics, and Lasers Conference, Atlanta, GA, May 12-14, 1986 . New York, American Society of Mechanical Engineers, 1986, p. 101-106. refs

A model representing the response of fixed or rotating axial compressor blade-rows is coupled to a 3-D numerical simulation of the flow outside the blade rows. The code can be used to study non-uniform compressible 3D flows through turbomachines. The fluid is assumed to be inviscid in the space outside the rows, while the viscous effects are taken into account inside. Numerical results are compared with steady distorted inflow. This comparison shows that this numerical approach is able to predict the response of the compressor. This work is part of a larger project aimed at predicting the response of a compressor to a nonuniform inlet flow that is periodic in time, or fully unsteady. Author

A86-40737#
CLEARANCE EFFECTS ON HEAT TRANSFER AT THE TIPS OF PLAIN AND GROOVED TURBINE AIRFOILS
D. E. METZGER and M. K. CHYU (Arizona State University, Tempe) IN: Turbomachinery performance deterioration; Proceedings of the Fourth Joint Fluid Mechanics, Plasma Dynamics, and Lasers Conference, Atlanta, GA, May 12-14, 1986 . New York, American Society of Mechanical Engineers, 1986, p. 107-113. refs

Heat transfer from the hot working gases and the resulting temperature levels and gradients at the tips of axial turine blades are important factors affecting service life and possible performance deterioration in gas turbine engines. Until very recently, there was little quantitative information available on blade tip heat transfer for even simple plain flat tips and a near total absence of knowledge of the nature of the convective heat transfer mechanisms involved. The evolution of various tip geometrical treatments, such as grooving, has been based largely on trial and error rather than on an understanding of the phenomena involved. The status of present knowledge on plain tip heat transfer is discussed, and results from an experimental and numerical study of grooved tip geometries are presented. Grooving is shown to be either beneficial or detrimental from the standpoint of total tip heat transfer, depending on the groove geometry. Author

A86-40738#
PERFORMANCE DETERIORATION DURING ROTATING STALL IN AXIAL COMPRESSORS
P. B. SHARMA (Indian Institute of Technology, New Delhi, India), J. W. RAILLY (Birmingham, University, England), and D. T. PAPAGEORGIOU IN: Turbomachinery performance deterioration; Proceedings of the Fourth Joint Fluid Mechanics, Plasma Dynamics, and Lasers Conference, Atlanta, GA, May 12-14, 1986 . New York, American Society of Mechanical Engineers, 1986, p. 115-122. Research supported by Rolls-Royce, Ltd. refs

Experiments on three axial compressors having hub-tip ratios of 0.4, 0.66 and 0.71 are reported to illustrate the effects of various parameters such as rotor stagger, aspect ratio, hub tip ratio and the exit boundary condition on the level of pressure rise to which the compressor operation deteriorates at occurrence of rotating stall. It has been found that the pressure rise during stall varies with the above factors. The continuance of full span rotating stall to low blockage values of 6-15 percent is found to be associated with the overlap between stalled and unstalled characteristics. Hysteresis and overlap both are found to vary with hub-tip ratio and aspect ratio. Author

A86-40739*# Purdue Univ., West Lafayette, Ind.
DIRECT AND SYSTEM EFFECTS OF WATER INGESTION INTO JET ENGINE COMPRESORS
S. N. B. MURTHY, C. M. EHRESMAN, and T. HAYKIN (Purdue University, West Lafayette, IN) IN: Turbomachinery performance deterioration; Proceedings of the Fourth Joint Fluid Mechanics, Plasma Dynamics, and Lasers Conference, Atlanta, GA, May 12-14, 1986 . New York, American Society of Mechanical Engineers, 1986, p. 127-141. NASA-FAA-supported research. refs

Water ingestion into aircraft-installed jet engines can arise both during take-off and flight through rain storms, resulting in engine operation with nearly saturated air-water droplet mixture flow. Each of the components of the engine and the system as a whole are affected by water ingestion, aero-thermally and mechanically. The greatest effects arise probably in turbo-machinery. Experimental and model-based results (of relevance to 'immediate' aerothermal changes) in compressors have been obtained to show the effects of film formation on material surfaces, centrifugal redistribution of water droplets, and interphase heat and mass transfer. Changes in the compressor performance affect the operation of the other components including the control and hence the system. The effects on the engine as a whole are obtained through engine simulation with specified water ingestion. The interest is in thrust, specific fuel consumption, surge margin and rotational speeds. Finally two significant aspects of performance changes, scalability and controllability, are discussed in terms of characteristic scales and functional relations. Author

A86-41549
SUBSTANTIATION OF REGIMES FOR ACCELERATED EQUIVALENT TESTS OF GAS-TURBINE AEROENGINES [OBOSNOVANIE REZHIMOV USKORENNYKH EKVIVALENTNYKH ISPYTANII AVIATSIONNYKH GTD]
L. P. LOZITSKII, A. N. VETROV, and V. F. LAPSHOV (Kievskii Institut Inzhenerov Grazdanskoi Aviatsii, Kiev, Ukrainian SSR) Problemy Prochnosti (ISSN 0556-171X), April 1986, p. 73-77. In Russian. refs

After reviewing existing approaches to accelerated testing of gas-turbine aeroengines, a method is suggested for calculating equivalent accelerated test regimes. The method is based on a linear mathematical model expressing the engine's service life. The method provides simultaneous verification of service life for some structural engine elements. It is used to calculate the regimes for testing the service times of the turbine blade, the rotor bearing, and the compressor blade. It is also used to calculate the resonance regimes involving tests of the engine's dynamic durability. I.S.

A86-41691#
EFFECT OF ENGINE TECHNOLOGY ON ADVANCED FIGHTER DESIGN AND COST
O. HERRMANN and W. BIEHL (Messerschmitt-Boelkow-Blohm GmbH, Munich, West Germany) (International Council of the Aeronautical Sciences, Congress, 14th, Toulouse, France, September 9-14, 1984, Proceedings. Volume 1, p. 137-143) Journal of Aircraft (ISSN 0021-8669), vol. 23, June 1986, p. 472-476. Previously cited in issue 22, p. 3192, Accession no. A84-44943. refs

A86-41708*#
FLIGHT EFFECTS ON NOISE FROM COAXIAL DUAL FLOW. II - HEATED JETS
R. DASH (NASA, Ames Research Center, Moffett Field, CA) AIAA Journal (ISSN 0001-1452), vol. 24, June 1986, p. 940-947. refs (Contract NCC2-75)

This paper is a continuation of the study described in Part I and deals with the flight effects on noise from heated jets. The present work shows that coaxial exhaust flows with inverted profiles are much quieter than flows with conventional profiles. Among all possible coaxial configurations with only one of the streams heated conventional profile, inverted profile, and the variable stream control engine (VSCE) cycle - and holding constant mass flow and thrust, a VSCE cycle is the best possible engine cycle as it provides over 18-dB reduction in sound pressure level (as compared to

noise from a conventional profile cycle) at all angles, both statically and in flight. The study also indicates that, if both the coaxial streams are heated unequally, a duct-burning profile, combined with the variable stream control engine (DB-VSCE) concept, gives rise to a powerful coaxial device which generates the least noise, both statically and in flight. This concept will be of paramount importance as one of the most variable nozzle designs of the future. Author

A86-41726*# Texas A&M Univ., College Station.
NUMERICAL EVALUATION OF PROPELLER NOISE INCLUDING NONLINEAR EFFECTS
K. D. KORKAN, E. VON LAVANTE (Texas A&M University, College Station), and L. J. BOBER (NASA, Lewis Research Center, Cleveland, OH) AIAA Journal (ISSN 0001-1452), vol. 24, June 1986, p. 1043-1045. refs
(Contract NAG3-354)

Propeller noise in the acoustic near field is presently determined through the integration of the pressure-time history in the tangential direction of a numerically generated flowfield around a propfan of SR-3 type, including the shock wave system in the vicinity of the propeller tip. This acoustic analysis yields overall sound pressure levels, and the associated frequency spectra, as a function of observer location. O.C.

A86-42099
AFTER THE BIG TURBOFANS
J. MOXON Flight International (ISSN 0015-3710), vol. 129, May 24, 1986, p. 32, 34.

An evaluation is made of the configurational features and prospective performance gains of next-generation airliner engines that attempt to reduce specific fuel consumption below the state-of-the-art values for large turbofan engines. Attention is given to 60,000-lb thrust class engine concepts that maximize airflow bypass; these encompass an Advanced Ducted Propeller configuration, employing a gearbox and variable pitch blades that are enclosed in a conventional nacelle, the 'Contra Fan', which is an ungeared contrarotating ducted fan, and the contrarotating Unducted Fan. O.C.

A86-42425#
DEVELOPMENT OF 'CADEGA' CAD SYSTEM FOR AERO ENGINE DESIGN
I. KATSUMATA, T. FURUHASHI, J. TAKANO, Y. ISHIKAWA, and T. TAKAHASHI Ishikawajima-Harima Engineering Review (ISSN 0578-7904), vol. 26, March 1986, p. 136-140. In Japanese, with abstract in English.

This paper introduces the CADEGA (Computer Aided Design for Engine General Arrangement) system which is instrumental in aero engine development. Questions were addressed with regard to what CAD can do for engine design, how to introduce CAD, how to implement a new CAD system, and problems related to the present design. Some of the computer programs which have been developed to make this CAD system more effective are explained in detail. This CADEGA system consists of a stacking program which can automatically produce drawings of general engine arrangements through stacking instruction using the CAD data base called master profiles. CADEGA is fully applied to the V2500 Engine design and all the detailed design information is exchanged among parties (five nations in international collaboration) using the CAD data given from this system. Author

A86-42657#
AIR TURBINE TEST RESULTS FOR THREE TURBINE STAGES WITH VARYING RADIAL DISTRIBUTION OF CAMBER
T. C. FLAHERTY and A. C. GOMINHO (General Electric Co., Aircraft Engine Business Group, Lynn, MA) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 22nd, Huntsville, AL, June 16-18, 1986. 7 p.
(AIAA PAPER 86-1467)

Three high pressure ratio turbine stages were designed and tested, having different radial distributions of blading camber in both stator and rotor. The three turbines were designed to the same thermodynamic conditions, with radial distribution of throat area being given three variations: (1) approximately linear ('conventional' design); (2) open at mid-span and closed at hub and tip relative to conventional ('over-cambered'); and (3) closed at mid-span and opened at hub and tip ('de-cambered'). In order to make the radial camber distribution the only variable in the test series, axial width of the blading was varied radially so that all three designs would have the same radial distribution of Zweifel coefficient. The turbines were tested in a warm air facility with conventional fixed instrumentation and with traversing of the exit annulus by a five-hole probe. The over-cambered and de-cambered designs had lower efficiency than the conventional design. Stage exit survey results are presented as well as overall efficiency comparisons. The exit survey results include radial velocity components, and are presented in contour plots as well as radial plots of average quantities. Author

A86-42659#
COUNTER-ROTATION PROP-FAN OPTIMIZATION
R. E. OWENS, W. W. FERGUSON (United Technologies Corp., Engineering Div. East Hartford, CT), and D. M. MABEE (United Technologies Corp., Hamilton Standard Div., Windsor Locks, CT) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 22nd, Huntsville, AL, June 16-18, 1986. 13 p. refs
(AIAA PAPER 86-1470)

An analytical study was conducted to find the best counter-rotation Prop-Fan to power a 120-passenger transport aircraft with aft-mounted engines. Figures-of-merit used in this study were fuel burn, direct operating cost, and noise. Propfan variables studied were number of blades, tip speed, diameter, and activity factor. The effects of these parameters on the performance, weight, and cost of the Prop-Fan were estimated. These estimates were then used to determine propulsion system (including gearbox, engine, nacelle, and pylon) weight, cost, and performance. Influence coefficients were used to determine the effect of these on airplane fuel burn and direct operating cost. The effects of Prop-Fan diameter and weight on airplane configuration and tail size were also included in this analysis. A matrix of 144 Prop-Fans was evaluated in this manner. A number of specific cases were chosen from this matrix for FAR 36 far field (community) and near field (cabin) noise evaluation. Author

A86-42660#
TURBOPROP AND OPEN ROTOR PROPULSION FOR THE FUTURE
J. H. R. SADLER (Rolls-Royce, Ltd., Derby, England) and G. S. HODGES (Rolls-Royce, Ltd., Bristol, England) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 22nd, Huntsville, AL, June 16-18, 1986. 9 p.
(AIAA PAPER 86-1472)

The factors which influence operating cost of turboprop and open rotor propulsors are shown to vary with the engine application, leading to different optimum design solutions for different aircraft. Generalised relationships between turboprop aircraft design range, power requirements and operating costs breakdown are drawn, showing their influence on both thermodynamic cycle selection and individual component design. The changing effects of physical size on engine layout are also considered, together with the constraints of different engine installations. Conclusions are related to actual design exercises carried out for engines with power outputs ranging from 2000 to 12000 shp. Author

A86-42662#
TURBOFAN AND PROPFAN AS BASIS FOR FUTURE ECONOMIC PROPULSION CONCEPTS
H. GRIEB and D. ECKARDT (MTU Motoren- und Turbinen-Union Muenchen GmbH, Munich, West Germany) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 22nd, Huntsville, AL, June 16-18, 1986. 13 p.
(AIAA PAPER 86-1474)

While such advanced airliner powerplant configurations as the counterrotating propfan promise considerable reductions in fuel

consumption, their integration into aircraft poses design configuration problems requiring a fundamental reorientation. It is noted that the noise from single and counterrotation propfans leads to cabin noise level increases in wing-mounted engine configurations, as well as to structural problems involving center of gravity and maneuverability in the case of tail-mounted engines (which are more suitable with respect to cabin noise). Attention is presently given to a counterrotating shrouded fan, which synthesizes the advantages of turbofan and propfan engines to yield a configurationally optimal design. O.C.

A86-42672#
TURBINE AIRFOIL LCF LIFE PREDICTION VERIFICATION
F. O. SOECHTING (United Technologies Corp., Engineering Div., West Palm Beach, FL) and R. J. ALLEN (USAF, Wright Aeronautical Laboratory, Wright-Patterson AFB, OH) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 22nd, Huntsville, AL, June 16-18, 1986. 8 p.
(AIAA PAPER 86-1496)

An improved turbine airfoil low cycle fatigue (LCF) life prediction model is evaluated. Core engine tests were conducted in a LCF test facility to provide complete characterization of steady-state and transient environments. The procedure for verifying the airfoil metal temperature distribution predictions on a turbine airfoil are described; the internal and external heat transfer features are examined. The cooling design for the blade is discussed. The distribution of film effectiveness on the airfoil surface is predicted. The relation between the external heat transfer coefficient and the distribution of adiabatic wall temperature is analyzed. The airfoil metal temperature for thermal fatigue life predictions is verified. The LCF model considers the temperature and stress or strain range by utilizing thermal-mechanical fatigue test data for the super-alloys. It is noted that the LCF life mode and heat transfer model provide accurate prediction of the location of turbine airfoil crack initiation and a good estimate of LCF capability. I.F.

A86-42694#
ALTITUDE IGNITION/LEAN DECELERATION STUDY
J. R. TAYLOR and S. K. WIDENER (General Electric Co., Evendale, OH) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 22nd, Huntsville, AL, June 16-18, 1986. 9 p.
(AIAA PAPER 86-1530)

Combustor lean ignition and flame stability limits are prime considerations in the design of advanced turbine engines. The physical processes governing ignition and blowout are well understood qualitatively, but are not easily modeled or predicted. This paper presents ignition and blowout correlations for seven General Electric combustor designs. The purely empirical relations illustrate the lack of consistent trends from one design to the next; the influence of operating parameters cannot be generalized using current information. The empirical approach presented here is useful for analyzing performance of a given combustor design and provides important information regarding trends with operating variables. Author

A86-42698#
DEVELOPMENT OF THE BOEING 767 THRUST REVERSER
J. JACKSON (Boeing Commercial Airplane Co., Seattle, WA) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 22nd, Huntsville, AL, June 16-18, 1986. 7 p.
(AIAA PAPER 86-1536)

The Boeing 767 is a twin engine wide bodied commercial airplane powered by either Pratt and Whitney JT9D, or General Electric CF6 turbofan engines. This paper describes the development of the Boeing thrust reverser for the 767 airplane from configuration development to FAA certification. Unless otherwise stated the contents of this paper apply to both JT9D and CF6 installations. The requirements of the thrust reverser, together with details of each phase of development in meeting the requirements are presented. Particular attention is directed at Boeing's first use of Turbo Powered Simulator nacelles for wind tunnel thrust reverser model testing and the advantage of this technique over more conventional blowing nacelle models. Finally, in-service experience and reliabiity together with resolutions of associated problems are discussed. Author

A86-42701*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
DYNAMIC PRESSURE LOADS ASSOCIATED WITH TWIN SUPERSONIC PLUME RESONANCE
J. M. SEINER, J. C. MANNING (NASA, Langley Research Center, Hampton, VA), and M. K. PONTON (PRC Kentron International, Hampton, VA) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 22nd, Huntsville, AL, June 16-18, 1986. 10 p. refs
(AIAA PAPER 86-1539)

The phenomenon of twin supersonic plume resonance is defined and studied as it pertains to high level dynamic loads in the inter-nozzle region of aircraft like the F-15 and B1-A. Using a 1/40th scale model twin jet nacelle with powered choked nozzles, it is found that intense internozzle dynamic pressures are associated with the synchrophased coupling of each plume's jet flapping mode. This condition is found most prevalent when each plume's jet flapping mode has constituent elements composed of the B-type helical instability. Suppression of these fatigue bearing loads was accomplished by simple geometric modifications to only one plume's nozzle. These modifications disrupt the natural selection of the B-type mode and thereby decouple the plumes. Author

A86-42702*# General Motors Corp., Indianapolis, Ind.
ROTORCRAFT PROPULSION FOR YEAR 2000 PLUS
T. R. LARKIN, D. V. STATON, and H. C. MONGIA (General Motors Corp., Allison Gas Turbine Div., Indianapolis, IN) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 22nd, Huntsville, AL, June 16-18, 1986. 6 p. Army-supported research.
(Contract NAS3-24542)
(AIAA PAPER 86-1543)

The objective of this study was to identify high-payoff technologies for year 2000 small gas turbine engines for rotorcraft application. A current state-of-the-art technology Allison gas turbine engine was used as a baseline and three advanced concepts were studied: the simple cycle engine, a waste heat recovery cycle, and a wave rotor engine cycle. For the simple cycle engine, two general arrangements were considered: the traditional concentric spool arrangement and a nonconcentric spool arrangement. Both a regenerative and a recuperative cycle were studied for the waste heat recovery cycle. An extensive cycle optimization procedure was performed for each configuration under study using relative direct operating cost (DOC) as the figure of merit. A high pressure ratio nonconcentric engine provided the greatest reduction in DOC with a 16.5 percent improvement. Author

A86-42703*# Avco Lycoming Div., Stratford, Conn.
SMALL ENGINE TECHNOLOGY PAYOFFS FOR FUTURE COMMUTER AIRCRAFT
H. KAEHLER and W. SCHNEIDER (Avco Lycoming Textron, Stratford, CT) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 22nd, Huntsville, AL, June 16-18, 1986. 12 p. Army-supported research.
(Contract NAS3-24545)
(AIAA PAPER 86-1544)

High payoff technologies for a year 2000 regenerative cycle turboprop engine were identified for a 19 passenger commuter aircraft application. A series of engines incorporating eight levels of advanced technologies were studied and their impact on aircraft performance was evaluated. Four advanced technologies are recommended to achieve a potential reduction in fuel burn of 38.3 percent. At $1.00 per gallon fuel price, a potential direct operating cost (DOC) benefit of 12.5 percent is obtained. At $2.00 per gallon, the potential DOC benefit increases to 17.0 percent. Author

A86-42708#
A REPORT ON THE INITIAL TESTING OF THE LARGE SCALE ADVANCED PROP-FAN
C. L. DEGEORGE, J. E. TURNBERG, and H. S. WAINAUSKI (United Technologies Corp., Hamilton Standard Div., Windsor Locks, CT) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 22nd, Huntsville, AL, June 16-18, 1986. 10 p.
(AIAA PAPER 86-1551)

It is pointed out that the Large Scale Advanced Prop-Fan (LAP) represents the culmination of over ten years of effort to extend the operating envelope of the propeller from the .6 Mn levels attained by contemporary turboprop powered aircraft to the .8 Mn speeds of today's turbofan powered commercial airliners. The efficiency of the Prop-Fan should make it possible to design aircraft which are 15 percent to 25 percent more efficient than today's technologically most advanced turbofan powered airliners. A report is presented regarding the initial testing conducted under the LAP program. Attention is given to a description of the LAP, the instrumentation system, aspects of whirl rig testing, and the static rotor test. No barriers were discovered which would prevent a continuation of the studies with wind tunnel, engine, and flight test programs in 1986 and 1987. G.R.

A86-42710#
HIGH PERFORMANCE, STRATIFIED CHARGE ROTARY ENGINES FOR GENERAL AVIATION
R. E. MOUNT (John Deere Technologies International, Inc., Rotary Engine Div., Wood Ridge, NJ) and W. L. GREINER (Avco Lycoming Textron, Williamsport, PA) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 22nd, Huntsville, AL, June 16-18, 1986. 12 p. refs
(AIAA PAPER 86-1553)

This paper discusses the application of advanced and highly advanced technologies to the direct injected, liquid cooled, Jet-A fueled, Stratified Charge Rotary Engine for high specific output, advanced and highly advanced general aviation engines. Author

A86-42737*# Science Applications International Corp., Princeton, N.J.
COMPUTATIONAL MODELS FOR THE ANALYSIS/DESIGN OF HYPERSONIC SCRAMJET COMPONENTS. I - COMBUSTOR AND NOZZLE MODELS
S. M. DASH, N. SINHA, D. E. WOLF, and B. J. YORK (Science Applications International Corp., Propulsion Gas Dynamics Div., Princeton, NJ) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 22nd, Huntsville, AL, June 16-18, 1986. 20 p. refs
(Contract NAS1-16535)
(AIAA PAPER 86-1595)

An overview of computational models developed for the complete, design-oriented analysis of a scramjet propulsion system is provided. The modular approach taken involves the use of different PNS models to analyze the individual propulsion system components. The external compression and internal inlet flowfields are analyzed by the SCRAMP and SCRINT components discussed in Part II of this paper. The combustor is analyzed by the SCORCH code which is based upon SPLITP PNS pressure-split methodology formulated by Dash and Sinha. The nozzle is analyzed by the SCHNOZ code which is based upon SCIPVIS PNS shock-capturing methodology formulated by Dash and Wolf. The current status of these models, previous developments leading to this status, and, progress towards future hybrid and 3D versions are discussed in this paper. Author

A86-42751#
A NOZZLE DESIGN ANALYSIS TECHNIQUE
J. J. BROWN (Boeing Commercial Airplane Co., Seattle, WA) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 22nd, Huntsville, AL, June 16-18, 1986. 11 p. refs
(AIAA PAPER 86-1613)

A method for calculating the flowfield in propulsive nozzles is presented. The complete set of partial differential equations for time-dependent, compressible, viscous flow is solved using an efficient numerical procedure. The flowfield is subdivided into rectangular regions called cells. The fluxes of conserved properties (mass, momentum, and energy) into each cell are balanced using a finite-volume approach. Solid boundary conditions are enforced using an imaginary row of cells inside the body. The inflow and outflow boundary conditions are enforced using a method of characteristics formulation. The method uses the line Gauss-Seidel implicit technique of MacCormack to solve the Reynolds-averaged Navier-Stokes equations in the computational domain. The Baldwin-Lomax algebraic turbulence model is used to include the subgrid effects of turbulence. Multistream, axisymmetric nozzle flowfields, including mixing of the streams, can be analyzed using this method. A fan nozzle thrust reverser can be analyzed as well. Results are presented for a converging-diverging propulsive nozzle, a three-stream turbofan nozzle, and a turbofan nozzle with thrust reverser. The computational results show excellent agreement with the experimental data. A two-order of magnitude reduction in run cost relative to the MacCormack explicit method is demonstrated. Author

A86-42755*# Purdue Univ., West Lafayette, Ind.
TRANSIENT ENGINE PERFORMANCE WITH WATER INGESTION
T. HAYKIN and S. N. B. MURTHY (Purdue University, West Lafayette, IN) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 22nd, Huntsville, AL, June 16-18, 1986. 21 p. refs
(Contract NAG3-481)
(AIAA PAPER 86-1621)

The immediate effects on the transient performance of a generic, high bypass ratio jet engine on account of water ingestion are discussed. The air compression subsystem has been analyzed with respect to four aerothermodynamic and mechanical processes associated with two-phase fluid flow and the engine simulation has been carried out under three limiting cases of interest in practice, one pertaining to draining of water at the end of compression and the other two, to partial evaporation at two different locations in the burner. General observations are made on engine operability as a function of engine and control design under various engine and (control input) sensor operating conditions, with various mass fractions of water in the air-water mixture entering the engine, during various pilot-initiated power demand changes. Author

A86-42757#
SMALL TURBOSHAFT/TURBOPROP ENGINE TECHNOLOGY STUDY
R. HIRSCHKRON and C. J. RUSSO (General Electric Co., Lynn, MA) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 22nd, Huntsville, AL, June 16-18, 1986. 11 p.
(AIAA PAPER 86-1623)

A study was conducted on turboshaft/turboprop engines in a nominal 850 shp size to determine advanced technology payoff in typical aircraft missions. Payoff was evaluated vs a reference engine based on current technology. The results indicate worthwhile areas of development in compressor and turbine aerodynamic viscous codes, ceramic composite materials, and advanced ceramic recuperators. An advanced simple cycle engine could demonstrate a 20 percent fuel saving and a 24 percent life cycle cost (LCC) reduction vs current engines. An advanced recuperative engine increases the fuel reduction potential to 37 percent, but with a smaller LCC improvement. An engine incorporating far term, post year 2000 technologies could reach fuel savings reductions of 50 percent. Author

A86-42758#
SMALL ENGINE PROPULSION READINESS FOR THE 21ST CENTURY
J. A. ALCORTA (United Technologies Corp., Pratt and Whitney, West Palm Beach, FL) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 22nd, Huntsville, AL, June 16-18, 1986. 8 p.
(AIAA PAPER 86-1624)

Attention is given to advanced component technologies that can impart significant performance improvements to small turbine

engines, such as may be applied to land vehicles, cruise missiles, helicopters, private aircraft and auxiliary power units. These technologies, which encompass modified compressor blading, ceramic combustors, actively cooled radial inflow turbines, advanced Ti alloys, intermetallic materials, and improved bearings, can when integrated yield 20-30 percent reductions in fuel consumption while improving specific power by 50 percent over current comparable engines. O.C.

A86-42759#
PROPFAN TEST ASSESSMENT (PTA) QUICK ENGINE CHANGE (QEC) NACELLE
T. BRADLAUGH-DREDGE (Rohr Industries, Inc., Chula Vista, CA) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 22nd, Huntsville, AL, June 16-18, 1986. 6 p.
(AIAA PAPER 86-1626)

A flightworthy Quick Engine Change (QEC) nacelle consisting of upper, lower inlet nose and side cowl composite components mating with internal aluminum frames of steel V braces developed for NASA's Propfan Test Assessment (PTA) program. Loads imposed by the propfan, gearbox and power section of the drive system are transmitted through the gearbox mounts to the forward metallic frames and intercostals, and are then carried aft to the airframe interface through the upper and lower composite cowl panels and via the metallic V brace assemblies. P-3 common hardware was used whenever possible, and design considerations led to the evolution of a hybrid structure design combining external graphite epoxy composite cowling with P-3 common conventional metallic internal structure. Structural design analysis substantiation and critical structural element static and fatigue composite subelement tests were performed. R.R.

A86-42784#
DESIGN FOR ENGINE SUPPORTABILITY
F. C. GILLETTE, T. J. CHRISTIE, W. H. QUIGLEY, and J. M. SHIPMAN (United Technologies Corp., Engineering Div., West Palm Beach, FL) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 22nd, Huntsville, AL, June 16-18, 1986. 9 p.
(AIAA PAPER 86-1671)

Advanced weapon systems require greatly improved supportability to provide the levels of availability and readiness required to counter the emerging threat. This paper addresses a new design approach which has been implemented to ensure supportability. Supportability must be addressed early in the development cycle when it is most cost-effective to implement. The key elements of this new approach are a designer 'awareness' program, supportability reviews, comprehensive trade studies, early support tool involvement, and a full-scale engine mockup built early in the program. These changes in the design process have provided designers with an awareness of current engine maintenance and support concerns. Moreover, it has instilled a disciplined approach to resolve these issues on the next-generation fighter engine. The paper concludes with a discussion of how this new design approach benefits the user and the weapon system. Author

A86-42786#
A FAULT-TOLERANT 1750A ENGINE CONTROLLER
S. NELSON, W. STANTON, and J. VOLP (Charles Stark Draper Laboratory, Inc., Cambridge, MA) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 22nd, Huntsville, AL, June 16-18, 1986. 9 p.
(AIAA PAPER 86-1675)

Jet engine control is in a state of transition from traditional passive, hydro-mechanical to electronic. While actuation will remain hydro-mechanical, next generation engine controllers will most certainly be electronic and fault tolerant. This paper develops the rationale for fault-tolerant engine controllers. System trade-offs necessary to determine the appropriate level of redundancy are described, various fault-tolerant computer architectures are compared, and a 1750A fault-tolerant computer that was developed as a prototype for next generation engine control along with some of the lessons learned from that project are described. Author

A86-42787*# National Aeronautics and Space Administration. Flight Research Center, Edwards, Calif.
TEST AND EVALUATION OF THE HIDEC ENGINE UPTRIM ALGORITHM
R. J. RAY and L. P. MYERS (NASA, Flight Research Center, Edwards, CA) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 22nd, Huntsville, AL, June 16-18, 1986. 11 p. refs
(AIAA PAPER 86-1676)

The highly integrated digital electronic control (HIDEC) program will demonstrate and evaluate the improvements in performance and mission effectiveness that result from integrated engine-airframe control systems. Performance improvements will result from an adaptive engine stall margin mode, a highly integrated mode that uses the airplane flight conditions and the resulting inlet distortion to continuously compute engine stall margin. When there is excessive stall margin, the engine is uptrimmed for more thrust by increasing engine pressure ratio (EPR). The EPR uptrim logic has been evaluated and implemente into computer simulations. Thrust improvements over 10 percent are predicted for subsonic flight conditions. The EPR uptrim was successfully demonstrated during engine ground tests. Test results verify model predictions at the conditions tested. Author

A86-42788#
ADVANCES IN AERO ENGINE DYNAMICS
J. B. WYNNE (Rolls-Royce, Ltd., Filton, England) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 22nd, Huntsville, AL, June 16-18, 1986. 12 p. Research supported by the Ministry of Defence (Procurement Executive).
(AIAA PAPER 86-1677)

An account is given of state-of-the-art methods for aircraft turbine engine dynamic balancing at the design and design-verification stages; these are based on FEMs, in the case of engine models, and finite difference time-stepping, in the case of dynamic response prediction. Attention is given to the effects of such operational circumstances as the loss of blading through foreign object ingestion, the characteristics of squeeze film bearings, and the measurement and monitoring of engine vibration. The function of alarm levels, bearing alignment principles, and diagnostic methods are discussed. O.C.

A86-42789#
KNOWLEDGE-BASED SYSTEMS FOR ROTORDYNAMIC DIAGNOSTICS
B. B. AGGARWAL, J. C. GIORDANO (Mechanical Technology, Inc., Latham, NY), and S. J. PRZYBYLKO (USAF, Aero Propulsion Laboratory, Wright-Patterson AFB, OH) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 22nd, Huntsville, AL, June 16-18, 1986. 8 p.
(Contract F33615-85-C-2513)
(AIAA PAPER 86-1678)

The knowledge-based systems considered differ from traditional systems in that the knowledge base is separate from the decision-making logic of the program. Such a separation makes it possible to handle problems of much larger scope and complexity. The investigation described represents the first step in an effort concerned with the application of this technology to the turbine engine domain. Attention is given to gas turbine engine rotor diagnostics, the demonstration of a knowledge-based diagnostic system, a rotordynamic test rig, aspects of data acquisition, and a knowledge-based rotor diagnostic system. The detection of faults implanted in a laboratory test rig provided a successful demonstration of a knowledge-based rotordynamic diagnostic system. G.R.

A86-42790#
AN OVERVIEW OF USAF ENGINE DIAGNOSTIC SYSTEMS
S. J. THORNTON (USAF, Aeronautical Systems Div., Wright-Patterson AFB, OH) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 22nd, Huntsville, AL, June 16-18, 1986. 11 p. refs
(AIAA PAPER 86-1679)

A development history is presented for the U.S. Air Force's engine diagnostic systems, with attention to the automation of diagnostics first introduced in the F100 turbofan engine's Events History Recorder. Other efforts have involved the T-38 trainer's J85 turbojet Engine Health Monitoring System, the A-10 ground support aircraft's TF34 turbofan Turbine Engine Monitoring System, and the F-15 fighter's F100 turbofan Engine Diagnostics System. State-of-the-art systems are currently installed in the KC-135, B-1B, and F-16 aircraft. The Integrated Turbine Engine Monitoring System and Joint Advanced Fighter Engine diagnostic system (for the Advanced Tactical Aircraft), which are undergoing development are also discussed. O.C.

A86-42792#
SOLID FUEL GAS GENERATOR AIR
W. C. CALVO, K. L. CHRISTENSEN, and M. H. FEDUN (Aerojet TechSystems Co., Sacramento, CA) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 22nd, Huntsville, AL, June 16-18, 1986. 5 p.
(AIAA PAPER 86-1682)

This paper describes: (1) the Air TurboRamjet (ATR) engine cycle when using a Solid Fuel Gas Generator (SFGG) to drive the turbocompressor, (2) the computer codes that are used to establish the engine mechanical design and predict the design and off-design performance, and (3) a test bed ATR engine that will be tested in the near future to demonstrate the engine and the SFGG cycle. Author

A86-42818#
ADVANCED TURBINE ENGINE SIMULATION TECHNIQUE DEVELOPMENT AND APPLICATIONS TO TESTING
M. A. CHAPPELL (Sverdrup Technology, Inc., Arnold Air Force Station, TN) and E. G. BLEVINS (USAF, Wright Aeronautical Laboratories, Wright-Patterson AFB, OH) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 22nd, Huntsville, AL, June 16-18, 1986. 10 p. USAF-sponsored research. refs
(AIAA PAPER 86-1731)

The Advanced Turbine Engine Simulation Technique (ATEST) is digital computer simulation system for the prediction and correlation of both steady-state and transient engine performance. ATEST has been developed using both a modular concept which provides the flexibility to simulate arbitrary engine cycle configurations and a modified Newton-Raphson numerical method (matrix solver) to achieve convergence at both design and off-design operating points. In addition, ATEST has the capability to treat the specialized characteristics of a particular engine (turbine cooling air paths, Reynolds number effects, etc.) to the degree of detail required by the user. The technique has been developed around a collection of the best features of current advanced engine simulations used in government and industry. ATEST is intended for aircraft gas turbine engine cycles (e.g., single-spool turbojet, high-bypass turbofan, variable-cycle engine, etc.) but could also be used to simulate other physical systems, taking advantage of the modular structure. The ATEST has been successfully applied to a number of different turbine engine cycles. These cycles represent a wide spectrum of the different types of aircraft gas turbine engines and include a single-spool turbojet (J79), a dual-spool turbojet (J57), dual-spool mixed-flow turbofans (F100, F110, F109, F404), a dual-spool separate-flow turbofan (CFM56), a turboshaft engine (T64), and an unconventional cycle engine. The ATEST has been written in FORTRAN 77 and has been executed on a variety of digital computers, including the AMDAHL 5860, CRAY-XMP, and CYBER 7600. Author

A86-42823#
IMPROVED COMPRESSOR PERFORMANCE USING RECESSED CLEARANCE (TRENCHES) OVER THE ROTOR
D. C. WISLER and B. F. BEACHER (General Electric Co., Aircraft Engine Business Group, Cincinnati, OH) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 22nd, Huntsville, AL, June 16-18, 1986. 9 p. refs
(Contract F33615-81-C-2030)
(AIAA PAPER 86-1745)

A systematic investigation of the effects on compressor performance of recessing (trenching) the case over the rotor tips was conducted in a four-stage research compressor. Variations in the slope of the trench, the depth of the trench, rotor tip penetration into the trench, distances of start and termination of the trench relative to the blade edges, and rotor tip clearances were evaluated. The effects of each geometric parmeter upon compressor efficiency and stall margin were determined. An innovative sloped trench configuration was developed and found to be superior to any other trench configuration tested, giving in one case a 0.5 point improvement in efficiency without adversely affecting stall margin. Author

A86-42826#
USING DERIVATIVE ENGINE TECHNOLOGY TO ACHIEVE MATURITY GOALS
R. P. TAYLOR, F. BYRD, and E. A. YOUNG (General Electric Co., Aircraft Engine Business Group, Cincinnati, OH) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 22nd, Huntsville, AL, June 16-18, 1986. 11 p. refs
(AIAA PAPER 86-1752)

The use of 'Derivative' aircraft turbine engines is proving to be a surer, faster way of achieving the early engine maturity goals desired by engine producers and engine users alike. In addition, advanced Derivatives offer fuel burn reductions comparable to 'new' engines. In fact, only giant steps in engine technology can provide a significant improvement over today's mature Derivative engines. Author

A86-42830#
PERFORMANCE ESTIMATION OF THE MIXED FLOW, AFTERBURNING, COOLED, TWO-SPOOL TURBOFAN ENGINE WITH BLEED AND POWER EXTRACTION
J. D. MATTINGLY, W. H. HEISER (U.S. Air Force Academy, Colorado Springs, CO), and D. H. DALEY AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 22nd, Huntsville, AL, June 16-18, 1986. 29 p.
(AIAA PAPER 86-1757)

This paper develops a model of the mixed flow, afterburning turbofan engine used for preliminary engine cycle analysis and selection in the Propulsion Design course at the United States Air Force Academy and in the upcoming AIAA Education Series textbook Aircraft Engine Design. The simplified model of this complex engine cycle, while retaining the major engine design variables and predicting the engine off-design performance over a wide range of flight conditions and throttle settings, is understandable by senior engineering design students. A user friendly micro-computer program of the engine model has been developed and typical results are presented. Author

A86-43381
CALCULATION OF THE CHARACTERISTICS OF A MULTISTAGE GAS TURBINE WITH ALLOWANCE FOR THE CIRCUMFERENTIAL NONUNIFORMITY OF INLET TEMPERATURE [RASCHET KHARAKTERISTIK MNOGOSTUPENCHATOI GAZOVOI TURBINY S UCHETOM OKRUZHNOI NERAVNOMERNOSTI TEMPERATURY NA VKHODE]
V. IU. DOZORNOV, R. A. KILDEEV, and A. P. TUNAKOV Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 1, 1986, p. 22-25. In Russian.

A program (GROT) is described which makes it possible to calculate the performance characteristics of a multistage turbine with a nonuniform inlet-temperature field. Results are presented

for the single-stage turbine of a high-pressure turbofan engine. B.J.

A86-43383
GENERALIZATION OF EXPERIMENTAL DATA ON THE INTERNAL HYDRAULIC RESISTANCE OF LAMINATED POROUS MATERIALS [OBOBSHCHENIE OPYTNYKH DANNYKH PO VNUTRENNIM GIDRAVLICHESKIM SOPROTIVLENIIAM PRONITSAEMYKH VAFEL'NYKH MATERIALOV]
V. I. LOKAI and A. V. SHCHUKIN Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 1, 1986, p. 30-34. In Russian. refs

The paper considers the generalization of experimental data on laminated porous materials, used in cooling the components of high-temperature gas turbine engines. This generalization has the form of the dependence of the internal hydraulic resistance of the materials on the Reynolds number of the coolant flow. B.J.

A86-43390
THE DEVELOPMENT OF A MODEL FOR THE UNSTABLE OPERATION OF A TURBOCOMPRESSOR AND THE DESIGN OF A DEVICE TO PROTECT A GAS TURBINE ENGINE AGAINST STALLING AND SURGING [RAZRABOTKA MODELI NEUSTOICHIVOI RABOTY TURBOKOMPRESSORA I POSTROENIE USTROISTVA DLIA ZASHCHITY GTD OT POMPAZHA]
M. M. SHAKIRIANOV Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 1, 1986, p. 61-66. In Russian. refs

Changes in the operation of a turbocompressor during stalling and surging of the gas turbine engine are examined. A device has been developed which eliminates stalling-and-surging phenomena by acting on three control units of the powerplant. B.J.

A86-43393
MODELING THE COMBUSTION ZONE OF GAS-TURBINE-ENGINE COMBUSTION CHAMBERS [MODELIROVANIE ZONY GORENIIA KAMER SGORANIIA GTD]
V. M. IANKOVSKII Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 1, 1986, p. 73-76. In Russian. refs

A physical model of the combustion zone of a combustor with a 'closed' front unit is developed on the basis of an investigation of the jet-interaction region of the first band of apertures of the flame tube. A mathematical interpretation is given of the model, which consists of three interacting reactors. Numerical results are presented, and a comparison with experimental data confirms the adequacy of the model to the actual combustion process. B.J.

A86-43395
SMALL FILM-EVAPORATION TYPE COMBUSTION CHAMBER FOR A LOW-POWER GAS TURBINE ENGINE [MALORAZMERNAIA PLENOCHNO-ISPARITEL'NAIA KAMEKA SGORANIIA GTD MALOI MOSHCHOSTI]
V. N. AFROSIMOVA, E. I. KOZELSKII, and S. A. VOLOSHIN Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 1, 1986, p. 82-85. In Russian. refs

Film-evaporation mixing schemes are used in the design of low-toxicity combustion chambers. In the present paper, experimental results are given concerning the effectiveness of using a film-evaporation type combustion chamber in a low-power (10-20 kW) gas turbine engine with rigorous size limitations. The presence of an evaporator in the chamber makes possible a maximum reduction in the size of the combustion zone. The relative flowrate of the primary air is determined at which mixture combustion with high efficiency (not less than 99 percent) is achieved without leaving a residue in the chamber. B.J.

N86-28085*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
UNIFORM ENGINE TESTING PROGRAM PHASE 7: NASA LEWIS RESEARCH CENTER SECOND ENTRY
T. J. BIESIADNY, L. A. BURKARDT, M. ABDELWAHAB, W. M. BRAITHWAITE, T. A. KIRCHGESSNER, and D. SILVER Jul. 1986 69 p
(NASA-TM-87272; E-2971; NAS 1.15:87272) Avail: NTIS HC A04/MF A01 CSCL 21E

The propulsion and Energetics Panel, Working Group 15, of the Advisory Group for Aerospace Research and Development (AGARD) is sponsoring a Uniform Engine Testing Program (UETP). In this program, two jet engines were tested under identical conditions in certain NATO altitude and ground-level facilities as a means of correlating these facilities. With this second entry, NASA documented engine deterioration that may have occurred since inception of the UETP. Additionally, NASA investigated anomalies discovered during review of data from the five facilities which had participated in the program between the two NASA entries. Author

N86-28088*# National Aeronautics and Space Administration. Dryden (Hugh L.) Flight Research Center, Edwards, Calif.
TEST AND EVALUATION OF THE HIDEC ENGINE UPTRIM ALGORITHM
R. J. RAY and L. P. MYERS Jul. 1986 13 p Presented at the AIAA/ASME/SAE/ASEE 22nd Joint Propulsion Conference, Huntsville, Ala., 16-18 Jun. 1986
(NASA-TM-88262; H-1363; NAS 1.15:88262) Avail: NTIS HC A02/MF A01 CSCL 21E

The highly integrated digital electronic control (HIDEC) program will demonstrate and evaluate the improvements in performance and mission effectiveness that result from integrated engine-airframe control systems. Performance improvements will result from an adaptive engine stall margin mode, a highly integrated mode that uses the airplane flight conditions and the resulting inlet distortion to continuously compute engine stall margin. When there is excessive stall margin, the engine is uptrimmed for more thrust by increasing engine pressure ratio (EPR). The EPR uptrim logic has been evaluated and implemented into computer simulations. Thrust improvements over 10 percent are predicted for subsonic flight conditions. The EPR uptrim was successfully demonstrated during engine ground tests. Test results verify model predictions at the conditions tested. Author

N86-28946*# Massachusetts Inst. of Tech., Cambridge. Dept. of Aeronautics and Astronautics.
A SUPERSONIC FAN EQUIPPED VARIABLE CYCLE ENGINE FOR A MACH 2.7 SUPERSONIC TRANSPORT Final Report
T. S. TAVARES 22 Aug. 1985 107 p
(Contract NAG3-697)
(NASA-CR-177141; NAS 1.26:177141) Avail: NTIS HC A06/MF A01 CSCL 21E

The concept of a variable cycle turbofan engine with an axially supersonic fan stage as powerplant for a Mach 2.7 supersonic transport was evaluated. Quantitative cycle analysis was used to assess the effects of the fan inlet and blading efficiencies on engine performance. Thrust levels predicted by cycle analysis are shown to match the thrust requirements of a representative aircraft. Fan inlet geometry is discussed and it is shown that a fixed geometry conical spike will provide sufficient airflow throughout the operating regime. The supersonic fan considered consists of a single stage comprising a rotor and stator. The concept is similar in principle to a supersonic compressor, but differs by having a stator which removes swirl from the flow without producing a net rise in static pressure. Operating conditions peculiar to the axially supersonic fan are discussed. Geometry of rotor and stator cascades are presented which utilize a supersonic vortex flow distribution. Results of a 2-D CFD flow analysis of these cascades are presented. A simple estimate of passage losses was made using empirical methods. Author

N86-28947*# Teledyne CAE, Toledo, Ohio.
VARIABLE AREA RADIAL TURBINE FABRICATION AND TEST PROGRAM
C. ROGO Aug. 1986 91 p
(Contract NAS3-23173; DA PROJ. 1L1-61101-AH-45)
(NASA-CR-175091; NAS 1.26:175091; AVSCOM-TR-86-C-13)
Avail: NTIS HC A05/MF A01 CSCL 21E

A variable area radial turbine with a moveable nozzle sidewall was experimentally evaluated. The turbine was designed for an advanced variable capacity gas turbine rotorcraft engine. The turbine has a mass flow rate of 2.27 kg/sec (5.0 lbs/sec), and a rotor inlet temperature of 1477K (2200 F). Testing was conducted at a reduced inlet temperature, but the aerodynamic parameters and Reynolds numbers were duplicated. Overall performance was obtained for a range of nozzle areas from 50% to 100% of the maximum area. The test program determined the effect on performance of: (1) Moving the hub or shroud sidewall; (2) Sidewall-vane clearance leakage; (3) Vaneless space geometry change; and (4) Nozzle cooling flows. Data were obtained for a range of pressure ratios and speeds and are presented in a number of performance maps. Author

N86-28948# Turbomeca S. A. - Brevets Szydlowski, Bordes (France).
COMPRESSORS STUDY: IMPROVING THE EFFICIENCY OF A HIGH PERFORMANCE MULTISTAGE COMPRESSOR Final Report [ETUDE SUR LES COMPRESSORS: AMELIORATION DES RENDEMENTS DE COMPRESSEURS MULTIETAGES A HAUTES PERFORMANCES]
D. DEHONDT Jun. 1985 27 p In FRENCH
(Contract DRET-82-342)
(ESA-86-97192) Avail: NTIS HC A03/MF A01

The effect of prerotation at the inlet of each stage was tested on a two stage axial compressor. The technical specifications are 45000 turns/min, 3.35 Kg of air/sec, and a compression rate of 12. A mechanical and aerodynamic study was performed in order to reduce the Mach number at the inlet of the rotating blades. The results confirm that the introduction of prerotation in the design improves overall compressor efficiency. ESA

N86-28949# Societe Nationale d'Etude et de Construction de Moteurs d'Aviation, Paris (France).
PREDICTION OF THE STABILITY PERFORMANCE OF A TURBOREACTOR COMBUSTION CHAMBER Final Report [PREDICTION DES PERFORMANCES DE STABILITE D'UNE CHAMBRE DE TURBOREACTEURS]
C. FAVREAU, Y. CHAUVEAU, and M. DESAULTY 1985 41 p In FRENCH
(Contract DRET-83-34-502)
(SNECMA-YKC-3269/85; ESA-86-97196) Avail: NTIS HC A03/MF A01

A theoretical prediction method based on the decomposition of the actual combustion chamber in elementary reaction volumes which are described by a model is investigated. Aerodynamic characterization of the chamber, combustion chemistry models, and carburant distribution in the combustion chamber were studied. An algorithm was developed and experimentally verified. The proposed method leads to prediction models which describe CO pollution, efficiency, and combustion stability for a reasonably low computing cost. ESA

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AIRCRAFT STABILITY AND CONTROL

Includes aircraft handling qualities; piloting; flight controls; and autopilots.

A86-40681*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
THE MEASUREMENT OF AIRCRAFT PERFORMANCE AND STABILITY AND CONTROL AFTER FLIGHT THROUGH NATURAL ICING CONDITIONS
R. J. RANAUDO, K. L. MIKKELSEN, R. C. MCKNIGHT, R. F. IDE, A. L. REEHORST (NASA, Lewis Research Center, Cleveland, OH) et al. AIAA, AHS, CASI, DGLR, IES, ISA, ITEA, SETP, and SFTE, Flight Testing Conference, 3rd, Las Vegas, NV, Apr. 2-4, 1986. 46 p. Previously announced in STAR as N86-22582. refs
(AIAA PAPER 86-9758)

The effects of airframe icing on the performance and stability and control of a twin-engine commuter-class aircraft were measured by the NASA Lewis Research Center. This work consisted of clear air tests with artificial ice shapes attached to the horizontal tail, and natural icing flight tests in measured icing clouds. The clear air tests employed static longitudinal flight test methods to determine degradation in stability margins for four simulated ice shapes. The natural icing flight tests employed a data acquisition system, which was provided under contract to NASA by Kohlman Systems Research Incorporated. This system used a performance modeling method and modified maximum likelihood estimation (MMLE) technique to determine aircraft performance degradation and stability and control. Flight test results with artificial ice shapes showed that longitudinal, stick-fixed, static margins are reduced on the order of 5 percent with flaps up. Natural icing tests with the KSR system corroborated these results and showed degradation in the elevator control derivatives on the order of 8 to 16 percent depending on wing flap configuration. Performance analyses showed the individual contributions of major airframe components to the overall degradation in lift and drag. Author

A86-40766
THE DESIGN OF A SLIDING MODE CONTROLLER FOR DUTCH ROLL DAMPING IN A NON-LINEAR AIRCRAFT SYSTEM
P. P. ASLIN, R. J. PATTON (York, University, Heslington, England), and C. M. DORLING (Sheffield, University, England) IN: Control 85; Proceedings of the International Conference, Cambridge, England, July 9-11, 1985. Volume 2 . London/New York, Institution of Electrical Engineers/IEE Inspec, 1985, p. 435-439. refs

The design and application of a sliding mode VSS (variable structure system) controller to the lateral motion subsystem of an RPV are considered. The controller was designed using new results concerning VSS analysis, providing a rigorous design technique combining eigenvalue and eigenvector assignment. In addition, the robustness properties of this control were investigated by using the nonlinear control law with a full-six-DOF aerodynamic model of the aircraft. The degree of insensitivity achieved by the sliding design is examined, and it is shown that the VSS controller provides acceptable performance. The demands placed on the actuators were shown to be small, and little evidence of 'chatter' was apparent. B.J.

A86-40767
THE DESIGN OF MULTI-FUNCTIONAL FLIGHT CONTROLLERS FOR STRUCTURAL LOAD ALLEVIATION
A. BRADSHAW (Salford, University, England) and S. E. BURGE (British Aerospace, PLC, Weybridge, England) IN: Control 85; Proceedings of the International Conference, Cambridge, England, July 9-11, 1985. Volume 2 . London/New York, Institution of Electrical Engineers/IEE Inspec, 1985, p. 440-445. refs

A summary of a general control system design technique for the class of second-order multivariable systems is presented. This technique is particularly suited to the design of high-performance

multi-functional flight control-laws. Indeed, the presentation of real-time analogue computer-microprocessor simulation results demonstrates the performance achievable by the implementation of such control-laws, in that they most satisfactorily effect the required tasks of accurate pitch maneuvering while simultaneously alleviating wing loads induced by the maneuver and by discrete gusts even for naturally unstable aircraft. Author

A86-40771
ON THE RELATIONSHIP BETWEEN ROBUSTNESS TESTS AND THEIR APPLICATION TO HELICOPTER CONTROL SYSTEM DESIGNS
M. S. TOMBS and I. POSTLETHWAITE (Oxford University, England) IN: Control 85; Proceedings of the International Conference, Cambridge, England, July 9-11, 1985. Volume 2 . London/New York, Institution of Electrical Engineers/IEE Inspec, 1985, p. 464-468. SERC-supported research. refs

Various methods of using singular value inequalities in the frequency domain to analyze the robustness of a control system design are compared, with particular emphasis on the class of possible plant models allowed by those constraints which must be satisfied before an inequality test is applicable. The relationship between Lehtomaki's robustness test and an inverse Nyquist based test is established, the former being a special case of the latter. The combined test as presented in Postlethwaite and Foo (1983) has been demonstrated to apply when a plant has uncertain poles close to the imaginary axis. The tests are compared with respect to their application to a control system design based on an LQG robustness recovery procedure. A helicopter design example is considered which illustrates the degree of usefulness of the different tests, and also allows an evaluation of the LQG design procedure. B.J.

A86-42785#
A DESIGN APPROACH TO A PERFORMANCE SEEKING CONTROL
P. SHAW, J. FORGROVER (Northrop Corp., Aircraft Div., Hawthorne, CA), D. F. BERG, J. SWAN, S. ADIBHATLA (General Electric Co., Fairfield, CT) et al. AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 22nd, Huntsville, AL, June 16-18, 1986. 14 p. USAF-supported research. refs
(AIAA PAPER 86-1674)

An indirect adaptive control system is being developed that will optimize the performance of a combined aircraft-engine system by minimizing the fuel flow consumption for subsonic and supersonic cruise operation. The indirect approach first perturbs a model of the aircraft-engine system to establish the constrained gradient direction that will maximize the performance improvement rate. A gradient integration algorithm is then used to follow the non-linear gradient direction to optimum performance. The gradient search identifies incremental changes to the current control variable positions which are then transmitted to the control as revised demands. The aircraft and the engine control systems respond to the changes in their schedules by adjusting the control system actuators through normal control operation. The resultant control laws will be modeled and included in a high fidelity, six-degree-of-freedom aircraft-engine simulation incorporating advanced tactical fighter aircraft features. A comprehensive evaluation test plan, which includes an assessment of potentially long-term instability due to unmodeled dynamics, has been developed to evaluate this adaptive control system design. This paper discusses the design approach for an indirect adaptive trim control system which will optimize the performance of a combined aircraft and propulsion system. Author

A86-42913
EIGENSTRUCTURE SYNTHESIS OF AN OBLIQUE WING FLIGHT CONTROL SYSTEM
G. L. LARSON and K. W. WILLISTON (Rockwell International Corp., Los Angeles, CA) IN: Conference on Decision and Control, 24th, Fort Lauderdale, FL, December 11-13, 1985, Proceedings. Volume 1 . New York, Institute of Electrical and Electronics Engineers, Inc., 1985, p. 660-662. Research supported by Rockwell International Corp.

A flight control system design employing the recently developed linear control techniques of eigenstructure synthesis and command generator tracking is presented for an oblique wing fighter. The eigenvalues governing modal frequency and damping are developed such that the vehicle dynamics are compliant with MIL-F-8785c, 'Flying Qualities of Piloted Aircraft'. Eigenvectors are deterministically developed through output feedback in an attempt to achieve orthogonality, decoupling the symmetric and asymmetric modes of motion. The design is unique in that longitudinal and lateral/directional SAS are developed simultaneously using the same linear model. A simplified constrained controller is examined weighing complexity against performance, after which feed-forward gains are developed to translate desired pilot control to multisurface commands. For example, the NASA Oblique Wing Research Aircraft (OWRA) in transonic flight with the wing highly swept is presented as a demanding situation. Author

A86-42937
DESIGN ISSUES FOR FAULT TOLERANT-RESTRUCTURABLE AIRCRAFT CONTROL
J. S. ETERNO, J. L. WEISS, D. P. LOOZE, and A. WILLSKY (ALPHATECH, Inc., Burlington, MA) IN: Conference on Decision and Control, 24th, Fort Lauderdale, FL, December 11-13, 1985, Proceedings. Volume 2 . New York, Institute of Electrical and Electronics Engineers, Inc., 1985, p. 900-905. refs

Passive and active techniques for fault tolerance and aircraft control are discussed. The advantages of passive robust control and adaptive control for reconstructable flight control systems (RFCSs) are examined. The residual generation of signals, the decision process, and hypothesis test design for the failure detection and identification techniques are described. The uses of control mixer concept, gain scheduling, or artificial intelligence techniques for control system reconfiguration are analyzed. Flight control system (FCS) reconfiguration based on LQ design techniques is considered. An automatic redesign algorithm is utilized to modify the FCS to reconstruct the unfailed aircraft design while directly incorporating control bandwidth constraints; an example of the LQ based approach for fault tolerance and aircraft control is provided. The capabilities of a RFCS which incorporates a failure detection and isolation module, an automatic redesign module, and a robust multivariable flight control system are studied. I.F.

N86-28090*# Alphatech, Inc., Burlington, Mass.
INITIAL DESIGN AND EVALUATION OF AUTOMATIC RESTRUCTURABLE FLIGHT CONTROL SYSTEM CONCEPTS
J. L. WEISS, D. P. LOOZE, J. S. ETERNO, and D. B. GRUNBERG Jun. 1986 163 p
(Contract NAS1-17411)
(NASA-CR-178064; NAS 1.26:178064; AI-TR-269) Avail: NTIS HC A08/MF A01 CSCL 01C

Results of efforts to develop automatic control design procedures for restructurable aircraft control systems is presented. The restructurable aircraft control problem involves designing a fault tolerance control system which can accomodate a wide variety of unanticipated aircraft failure. Under NASA sponsorship, many of the technologies which make such a system possible were developed and tested. Future work will focus on developing a methodology for integrating these technologies and demonstration of a complete system. Author

N86-28092*# National Aeronautics and Space Administration. Dryden (Hugh L.) Flight Research Center, Edwards, Calif.
EFFECT OF TIME DELAY ON FLYING QUALITIES: AN UPDATE
R. E. SMITH and S. K. SARRAFIAN Aug. 1986 13 p Proposed for presentation at the AIAA Guidance, Navigation and Control Conference, Williamsburg, Va., 18-20 Aug. 1986
(NASA-TM-88264; H-1351; NAS 1.15:88264) Avail: NTIS HC A02/MF A01 CSCL 01C

Flying qualities problems of modern, full-authority electronic flight control systems are most often related to the introduction of additional time delay in aircraft response to a pilot input. These delays can have a significant effect on the flying qualities of the aircraft. Time delay effects are reexamined in light of recent flight test experience with aircraft incorporating new technology. Data from the X-29A forward-swept-wing demonstrator, a related preliminary in-flight experiment, and other flight observations are presented. These data suggest that the present MIL-F-8785C allowable-control system time delay specifications are inadequate or, at least, incomplete. Allowable time delay appears to be a function of the shape of the aircraft response following the initial delay. The cockpit feel system is discussed as a dynamic element in the flight control system. Data presented indicate that the time delay associated with a significant low-frequency feel system does not result in the predicted degradation in aircraft flying qualities. The impact of the feel system is discussed from two viewpoints: as a filter in the control system which can alter the initial response shape and, therefore, the allowable time delay, and as a unique dynamic element whose delay contribution can potentially be discounted by special pilot loop closures. Author

N86-28093*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
IMPLEMENTATION AND FLIGHT TESTS FOR THE DIGITAL INTEGRATED AUTOMATIC LANDING SYSTEM (DIALS). PART 2: COMPLETE SET OF FLIGHT DATA
R. M. HUESCHEN Jul. 1986 330 p
(NASA-TM-87632-PT-2; NAS 1.15:87632-PT-2) Avail: NTIS HC A15/MF A01 CSCL 17G

Five flight tests of the Digital Automated Landing System (DIALS) were conducted on the Advanced Transport Operating System (ATOPS) Transportation Research Vehicle (TSRV)--a modified Boeing 737 Aircraft for advanced controls and displays research. These flight tests were conducted at NASA's Wallops Flight Center using the Microwave Landing System (MLS) installation on Runway 22. This report is primarily a collection of data plots of all performance variables recorded for the entire five flight tests. A description and source of the performance variables is included. Performance variables include inertial data, air data, automatic control commands, control servo positions, sensor data, DIALS guidance and control parameters, and Kalman filter data. This data illustrates low overshoot captures of the localizer for intercept angles of 20 deg, 30 deg, 40 deg, and 50 deg intercept angles, and low overshoot captures of the glideslope slope for 3 deg, 4.5 deg, and 5 deg glideslopes. Flare maneuvers were successfully performed from the various glideslope angles and good decrab maneuvers were performed in crosswinds of 6 knots. In 18 to 20 knot crosswind conditions rudder limiting occurred which caused lateral drifting although heading alignment was achieved. Author

N86-28094# Deutsche Lufthansa Aktiengesellschaft, Cologne (West Germany).
CONTROL SYSTEMS FOR THE AIRBUS DESIGN AND FUNCTIONAL EXPERIENCE [LEITSYSTEME FUER DEN AIRBUS. AUFBAU UND BETRIEBSERFAHRUNG]
P. H. HELDT 1985 21 p In GERMAN Presented at Fachgespraechs der Gesellschaft fuer Reaktorsicherheit, Munich, West Germany, 8 Nov. 1985
(ESA-86-96936) Avail: NTIS HC A02/MF A01

The design of cockpits of modern passenger aircraft is illustrated by the Airbus 310. Basic rules of aircraft design are given. Important control systems are presented. The status of functional experience is outlined. The crew is taken into account as an integral part in order to correctly understand the global cockpit system. It is shown how the two tasks of pilots (flying and controlling) are integrated in the global concept of cockpit design, and the pilot qualifications required for these tasks are outlined. ESA

N86-28095# Societe Nationale Industrielle Aerospatiale, Toulouse (France).
EIGENVALUES ASSIGNMENT METHOD: AN APPLICATION TO DESIGNING AN AUTOPILOT
A. BUCHARLES (Departement d'Etudes et de Recherches en Technologie Spatiale, Toulouse, France), J. F. MAGNI, and O. HERAIL 1986 15 p In FRENCH; ENGLISH summary Presented at AFCET Salon Intern. des Tech. et Energies du Futur (SITEF 85), Toulouse, 24-25 Oct. 1985 Submitted for publication
(Contract STPA-83-95024; STPA-84-95016)
(SNIAS-861-111-106; ESA-86-97143) Avail: NTIS HC A02/MF A01

Eigenstructure assignment methods are shown to be a useful tool for computing control laws of multivariable systems. In a first step closed loop eigenvalues are to be assigned. The second step uses the degrees of freedom available on the eigenvectors for optimizing criteria relative to control objectives as output shaping, insensitivity, or disturbance decoupling. The degrees of freedom of eigenvectors are defined and it is shown how to obtain control objectives. The design of an autopilot is detailed to demonstrate the method's efficiency. ESA

N86-28096# Societe Nationale Industrielle Aerospatiale, Toulouse (France).
MAIN FLIGHT CONTROLS [COMMANDES DE VOL PRINCIPALES]
M. DURANDEAU 1986 30 p In FRENCH Presented at Ecole Nationale de l'Aviation Civile Conf., Toulouse, 22 May 1985
(SNIAS-861-111-111; ESA-86-97147) Avail: NTIS HC A03/MF A01

The A-320 aircraft flight control and avionics systems are illustrated. Safety, maintenance, and systems engineering aspects are listed. ESA

N86-28950*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
IMPLEMENTATION AND FLIGHT TESTS FOR THE DIGITAL INTEGRATED AUTOMATIC LANDING SYSTEM (DIALS). PART 1: FLIGHT SOFTWARE EQUATIONS, FLIGHT TEST DESCRIPTION AND SELECTED FLIGHT TEST DATA
R. M. HUESCHEN Jul. 1986 135 p
(NASA-TM-87632-PT-1; NAS 1.15:87632-PT-1) Avail: NTIS HC A07/MF A01 CSCL 01C

Five flight tests of the Digital Automated Landing System (DIALS) were conducted on the Advanced Transport Operating Systems (ATOPS) Transportation Research Vehicle (TSRV) -- a modified Boeing 737 aircraft for advanced controls and displays research. These flight tests were conducted at NASA's Wallops Flight Center using the microwave landing system (MLS) installation on runway 22. This report describes the flight software equations of the DIALS which was designed using modern control theory direct-digital design methods and employed a constant gain Kalman filter. Selected flight test performance data is presented for localizer (runway centerline) capture and track at various intercept angles, for glideslope capture and track of 3, 4.5, and 5 degree glideslopes, for the decrab maneuver, and for the flare maneuver. Data is also presented to illustrate the system performance in the presence of cross, gust, and shear winds. The mean and standard deviation of the peak position errors for localizer capture were, respectively, 24 feet and 26 feet. For mild wind conditions, glideslope and localizer tracking position errors did not exceed, respectively, 5 and 20 feet. For gusty wind conditions (8 to 10 knots), these errors were, respectively, 10 and 30 feet. Ten hands off automatic lands were performed. The standard deviation of the touchdown position and velocity errors from the mean values were, respectively, 244 feet and 0.7 feet/sec. Author

N86-28951*# Kansas Univ. Center for Research, Inc., Lawrence.
INVESTIGATION OF EMPENNAGE BUFFETING
C. E. LAN, I. G. LEE, and W. H. WENTZ (Wichita State Univ., Kans.) Jul. 1986 81 p
(Contract NAG2-371)
(NASA-CR-177164; NAS 1.26:177164; CRINC-FRL-714-1) Avail: NTIS HC A05/MF A01 CSCL 01C

Theoretical methods of predicting aircraft buffeting are reviewed. For the buffeting due to leading edge vortex breakdown, a method is developed to convert test data of mean square values of fluctuating normal force to buffeting vortex strength through an unsteady lifting-surface theory and unsteady suction analogy. The resulting buffeting vortex from the leading edge extension of an F-18 configuration is used to generate a fluctuating flow field which produces unsteady pressure distribution on the vertical tails. The root mean square values of root bending moment on the vertical tails are calculated for a rigid configuration. Author

N86-28952*# Purdue Univ., West Lafayette, Ind. School of Aeronautics and Astronautics.
THE INTEGRATED MANUAL AND AUTOMATIC CONTROL OF COMPLEX FLIGHT SYSTEMS Status Report, Apr. 1985 - Jun. 1986
D. K. SCHMIDT 7 Jul. 1986 27 p
(Contract NAG4-1)
(NASA-CR-177086; NAS 1.26:177086) Avail: NTIS HC A03/MF A01 CSCL 01C

The topics of research in this program include pilot/vehicle analysis techniques, identification of pilot dynamics, and control and display synthesis techniques for optimizing aircraft handling qualities. The project activities are discussed. The current technical activity is directed at extending and validating the active display synthesis procedure, and the pilot/vehicle analysis of the NLR rate-command flight configurations in the landing task. Two papers published by the researchers are attached as appendices. E.R.

N86-28953*# Massachusetts Inst. of Tech., Cambridge. Lab. for Information and Decision Systems.
MULTIVARIABLE CONTROL OF A FORWARD SWEPT WING AIRCRAFT M.S. Thesis
W. W. QUINN Jan. 1986 137 p
(Contract NAG2-297)
(NASA-CR-177112; NAS 1.26:177112; LIDS-TH-1530) Avail: NTIS HC A07/MF A01 CSCL 01C

The impact of independent canard and flaperon control of the longitudinal axis of a generic forward swept wing aircraft is examined. The Linear Quadratic Gaussian (LQG)/Loop Transfer Recovery (LTR) method is used to design three compensators: two single-input-single-output (SISO) systems, one with angle of attack as output and canard as control, the other with pitch attitude as output and canard as control, and a two-input-two-output system with both canard and flaperon controlling both the pitch attitude and angle of attack. The performances of the three systems are compared showing the addition of flaperon control allows the aircraft to perform in the precision control modes with very little loss of command following accuracy. Author

N86-28954*# Massachusetts Inst. of Tech., Cambridge. Dept. of Aeronautics and Astronautics.
INDIVIDUAL-BLADE-CONTROL RESEARCH IN THE MIT VTOL TECHNOLOGY LABORATORY 1977-1985 Final Report, Nov. 1977 - Nov. 1985
N. D. HAM Jun. 1986 40 p
(Contract NSG-2266)
(NASA-CR-177121; NAS 1.26:177121; VTL-TR-196-8) Avail: NTIS HC A03/MF A01 CSCL 01C

A new, advanced system for active control of helicopters and its application to the solution of rotor aerodynamic and aeroelastic problems is described. Each blade is individually controlled in the rotating frame over a wide range of frequencies. Application of the system to gust alleviation, attitude stabilization, vibration alleviation, blade lag damping augmentation, stall flutter suppression, blade flapping stabilization, stall alleviation, and performance enhancement is outlined. The effectiveness of the system in achieving most of these applications is demonstrated by experimental results from wind tunnel tests of a model helicopter rotor with individual blade control. The feasibility of achieving many or all of the applications of individual blade control using the conventional helicopter swash plate is demonstrated, and the necessary control laws are presented. Author

N86-28955*# Purdue Univ., West Lafayette, Ind. School of Aeronautics and Astronautics.
MULTI-INPUT, MULTI-OUTPUT SYSTEM CONTROL FOR EXPERIMENTAL AIRCRAFT Progress Report
D. K. SCHMIDT and E. L. DUKE 13 Dec. 1985 57 p
(Contract NCC2-288)
(NASA-CR-177017; NAS 1.26:177017) Avail: NTIS HC A04/MF A01 CSCL 01C

Two techniques, direct eigenspace assignment (DEA) and explicit model following (EMF), are used initially to synthesize control laws for the longitudinal dynamics model of a Short Takeoff and Landing (STOL) vehicle in the landing configuration. The vehicle model and the flight control design are presented. The two synthesis techniques are briefly discussed and the handling qualities specifications mapped into the algorithm formulations. The control laws resulting from exercising the algorithms are evaluated in terms of achieved performance and robustness. Since the synthesized control laws involve full state feedback, methodologies were implemented for the control laws using output feedback without adversely affecting performance and robustness. Finally, the salient features of the two design techniques are summarized and the areas that require further investigation are suggested. B.G.

N86-28956*# Massachusetts Inst. of Tech., Cambridge. Lab. for Information and Decision Systems.
MULTIVARIABLE CONTROL OF A TWIN LIFT HELICOPTER SYSTEM USING THE LQG/LTR DESIGN METHODOLOGY
A. A. RODRIGUEZ and M. ATHANS 1986 8 p
(Contract NAG2-297)
(NASA-CR-177025; NAS 1.26:177025; LIDS-P-1551) Avail: NTIS HC A02/MF A01 CSCL 01C

Guidelines for developing a multivariable centralized automatic flight control system (AFCS) for a twin lift helicopter system (TLHS) are presented. Singular value ideas are used to formulate performance and stability robustness specifications. A linear Quadratic Gaussian with Loop Transfer Recovery (LQG/LTR) design is obtained and evaluated. Author

N86-28957*# Florida Atlantic Univ., Boca Raton. Dept. of Mechanical Engineering.
AN EXPERIMENTAL AND ANALYTICAL INVESTIGATION OF ISOLATED ROTOR FLAP-LAG STABILITY IN FORWARD FLIGHT
G. H. GAONKER, M. J. MCNULTY (Army Research and Technology Labs., Moffett Field, Calif.), and J. NAGABHUSHAN (Indian Inst. of Science, Bangalore) Sep. 1985 31 p Presented at the 11th European Rotorcraft Forum, London, England, 10-13 Sep. 1985
(Contract NCC2-361)
(NASA-CR-177028; NAS 1.26:177028; PAPER-66) Avail: NTIS HC A03/MF A01 CSCL 01C

For flap-lag stability of isolated rotors, experimental and analytical investigations are conducted in hover and forward flight on the adequacy of a linear quasisteady aerodynamics theory with dynamic inflow. Forward flight effects on lag regressing mode are emphasized. A soft inplane hingeless rotor with three blades is tested at advance ratios as high as 0.55 and at shaft angles as high as 20 degrees. In combination with lag natural frequencies, collective pitch settings and flap-lag coupling parameters, the data base comprises nearly 1200 test points (damping and frequency) in forward flight and 200 test points in hover. By computerized symbolic manipulations, an analytic model is developed in substall to predict stability margins with mode identification. It also predicts

substall and stall regions to help explain the correlation between theory and data. Author

N86-28958*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
NONLINEAR CONTROL OF AIRCRAFT
L. R. HUNT (Texas Technological Univ., Lubbock), G. MEYER, and R. SU 1984 10 p
(Contract NAG2-189; NAG2-203; N00014-76-C-1136)
(NASA-TM-89225; NAS 1.15:89225) Avail: NTIS HC A02/MF A01 CSCL 01C

Transformations of nonlinear systems were used to design automatic flight controllers for vertical and short takeoff aircraft. Under the assumption that a nonlinear system can be mapped to a controllable linear system, a method using partial differential equations was constructed to approximate transformations in cases where exact ones cannot be found. An application of the design theory to a rotorcraft, the UH-1H helicopter, was presented. Author

N86-28959*# California Polytechnic State Univ., San Luis Obispo. Dept. of Aeronautical Engineering.
FLUTTER PREDICTION FOR A WING WITH ACTIVE AILERON CONTROL Final Report
K. PENNING and D. R. SANDLIN Jun. 1983 112 p
(Contract NCC4-1)
(NASA-CR-176994; NAS 1.26:176994) Avail: NTIS HC A06/MF A01 CSCL 01C

A method for predicting the vibrational stability of an aircraft with an analog active aileron flutter suppression system (FSS) is expained. Active aileron refers to the use of an active control system connected to the aileron to damp vibrations. Wing vibrations are sensed by accelerometers and the information is used to deflect the aileron. Aerodynamic force caused by the aileron deflection oppose wing vibrations and effectively add additional damping to the system. Author

N86-28960*# National Aeronautics and Space Administration, Washington, D.C.
OPTICAL TECHNOLOGY FOR FLIGHT CONTROL SYSTEMS
M. MAYANAGI Mar. 1986 29 p Transl. into ENGLISH from Japan Society for Aeronautical and Space Sciences Journal (Japan), v. 32, no. 369, Oct. 1984 p 583-593 Transl. by Kanner (Leo) Associates, Redwood City, Calif.
(Contract NASW-4005)
(NASA-TM-88400; NAS 1.15:88400; ISSN-0021-4663) Avail: NTIS HC A03/MF A01 CSCL 01C

Optical applications to the flight control system including optical data bus, sensors, and transducers are analyzed. Examples of optical data bus include airborne light optical fiber technology (ALOFT), F-5E, YA-7D, MIL-STD-1553 fiber optic data bus and NAL-optic data bus. This NAL-optic data bus is applied to STOL, and its characteristics are stressed. Principles and advantages of optical pulse-digital transducers are discussed. Author

09

RESEARCH AND SUPPORT FACILITIES (AIR)

Includes airports, hangars and runways; aircraft repair and overhaul facilities; wind tunnels; shock tube facilities; and engine test blocks.

A86-40226
STOLPORT LONDON - A DESIGN FOR SAFETY
I. BROOM (Gatwick Handling, Ltd., Horley; Plessey Airports, Ltd., Weybridge, England) International Journal of Aviation Safety (ISSN 0264-6803), vol. 3, Sept. 1985, p. 166-170.

An evaluation is made of the range of design planning and operations integration considerations that have shaped the STOLport currently under construction in the center of London. The STOLport is intended exclusively for commuter airliners that are able to at least match the noise output and IFR runway requirements of the four-engine DHC-7 aircraft. Attention is given to runway design, residential considerations, noise minimization requirements, and navigational resources of the London area. O.C.

A86-40477
FLIGHT SIMULATOR UPGRADES AND MODIFICATIONS
P. V. PRABHU and N. K. AGARWAL (GMI, Broken Arrow, OK) IN: Simulators; Proceedings of the Conference, Norfolk, VA, March 3-8, 1985 . La Jolla, CA, Society for Computer Simulation, 1985, p. 1-5.

In connection with the arising need for additional capability to train pilots in a flight simulator, a cost-effective alternative to the procurement of a new simulator can be the upgrading modification of an existing simulator. Benefits of such an alternative are related to lower procurement cost and shorter delivery time. Areas of update are discussed, taking into account aircraft modifications, new government standards, new aircraft data, new training requirements, and aspects of maintainability. Questions of industry performance are investigated, and areas of concern are examined. In addition to the solution of other problems, an exact definition of the improvements to be achieved by the upgrade of the simulator needs to be established. G.R.

A86-42170
SOFTWARE POSITION AND VELOCITY LIMITING FOR A SYNERGISTIC SIX DEGREE-OF-FREEDOM MOTION SYSTEM
D. R. CAMPBELL (Paisley College of Technology, Scotland) Aeronautical Journal (ISSN 0001-9240), vol. 90, April 1986, p. 121-127. refs

The cross-coupling effect of the hardware and software limiting of motion platform hydraulic jacks' velocity and displacement, which leads to spurious cue generation in the range below 2 Hz, has in the past been ignored. It is presently noted that the setting of software limits and the scaling of jack demands with respect to both this limit and the maximum jack demand yields a limiting strategy that maintains acceleration cue directional fidelity; such a simple scheme encompasses a soft limiting approach for motion jerk reduction, and requires negligible extra computing time or storage. O.C.

A86-42606#
A COMPUTATIONAL FLUID DYNAMICS EVALUATION OF TEST CELL RECIRCULATION EFFECTS ON HIGH-BYPASS TURBOFAN ENGINE SURFACE PRESSURE DISTRIBUTIONS
D. H. HUDDLESTON, G. K. COOPER, and W. J. PHARES (Sverdrup Technology, Inc., Arnold Air Force Station, TN) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 22nd, Huntsville, AL, June 16-18, 1986. 6 p. refs
(AIAA PAPER 86-1384)

A computational fluid dynamics analysis of an engine exhaust/test cell/diffuser combination is presented. The full Reynolds-averaged Navier-Stokes equations are solved by application of a Beam-Warming algorithm on a numerically generated, body-fitted computational grid. Axisymmetric numerical results and correlations with experiment are presented for a high-bypass turbofan engine and for a subscale turbofan model. The correlations with experiment indicate that the current solution technique provides both a qualitative (overall flow field) and quantitative (surface pressure distribution) analysis capability for engine exhaust/test cell/diffuser flows including test cell recirculation. The results presented indicate a potential for applying this technology to the assessment and correction of test cell effects in high-bypass turbofan engine testing. Author

A86-42661#
UHB TECHNOLOGY FLIGHT VALIDATION PROGRAM
R. VANT RIET, W. T. LEWERENZ, and J. E. DONELSON (Douglas Aircraft Co., Long Beach, CA) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 22nd, Huntsville, AL, June 16-18, 1986. 11 p.
(AIAA PAPER 86-1473)

An overview of the development of an Ultra High Bypass (UHB) technology demonstrator is presented. The potential benefits and critical technology issues of UHB technology are reviewed. The structural modifications required to convert an MD-80 into a flight demonstration vehicle are described. The goals and schedule of the upcoming flight test program are presented. Author

A86-42769#
A TURBINE ENGINE INLET VIEWING SYSTEM
R. A. BELZ, C. W. BRASIER, P. J. MURPHY, and T. D. DAVIS (Sverdrup Technology, Inc., Arnold Air Force Station, TN) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 22nd, Huntsville, AL, June 16-18, 1986. 9 p.
(AIAA PAPER 86-1647)

A video imaging system has been developed for turbine engine testing at the Arnold Engineering Development Center to allow observation of individual fan blades, stator blades, and the spinner surface area while the engine is running. The system utilizes off-the-shelf hardware including a strobed laser light source, a fiber-optical cable, and a high-sensitivity video camera to view the inlet in stop motion. Laser strobing is synchronized to the engine rotation for fan and spinner analysis. The system was used to observe ice buildup and shedding on the fan blades and spinner during an engine icing test. Blade-case rubbing was also observed during the test. The strobed laser system is described, ice formations observed on the spinner and fan blades are presented, and applications and planned future improvements to the system are described. Author

A86-42814#
CHARACTERIZATION OF FUEL SPRAYS USING A HIGH-RESOLUTION PATTERNATOR
J. B. MCVEY, S. RUSSELL, and J. B. KENNEDY (United Technologies Research Center, East Hartford, CT) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 22nd, Huntsville, AL, June 16-18, 1986. 17 p. refs
(AIAA PAPER 86-1726)

The features of a high-resolution patternation system used for measuring the spatial distribution of mass flux delivered by large-volume-flow gas turbine engine fuel injectors are described. The patternation system is based on the use of extractive probing by means of a multi-point sampling rake. Testing is conducted under ambient pressure conditions. Results of tests conducted to verify the capabilities of the system are presented.Applications of the system to establish the impact of injector aerodynamic and hydraulic design features on spray uniformity are discussed.
Author

A86-42819#
THEORETICAL AND EXPERIMENTAL INVESTIGATION OF TEST CELL AERODYNAMICS FOR TURBOFAN APPLICATIONS
A. I. KARAMANLIS, J. S. SOKHEY, T. C. DUNN, and D. C. BELLOMY (General Electric Co., Cincinnati, OH) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 22nd, Huntsville, AL, June 16-18, 1986. 12 p. Research supported by the General Electric Co. refs
(AIAA PAPER 86-1732)

This paper describes aerodynamic design, model testing and full scale checkout of a General Electric aircooled exhaust turbofan test facility. The purpose of the research and development work reported herein is to modify the existing test cell configuration to accept high and low bypass ratio turbofan engines with or without afterburner. A brief description of the scale model tests including engine simulation, model test facility and data reduction is given. The comparison of test cell characteristics, i.e., Front Cell Velocity Distortion, Front Cell Depression, Air Flow Rate, Exhaust System Flow Mixing and Temperatures between the model scale and full scale tests is presented. The theoretical results from engine/exhaust collector inviscid and viscous flow analyses, which were used to obtain preliminary exhaust system performance data are also presented. Correlations between full scale and model scale data reveal that the performance of a full scale test cell can be predicted using model scale tests thereby reducing test cell development costs. Author

N86-28099*# National Aeronautics and Space Administration, Washington, D.C.
CRYOGENIC WIND TUNNELS: PROBLEMS OF CONTINUOUS OPERATION AT LOW TEMPERATURES
D. FAULMANN Jun. 1986 52 p Transl. into ENGLISH of "Souffleries Cryogeniques Problemses Lies au Fonctionnement Continue en Basse Temperature" rept. OA-9/5007-AYD, DERAT-9/5007-DY ONERA, Toulouse, France, Jun. 1980 p 1-18 Transl. by Kanner (Leo) Associates, Redwood City, Calif.
(Contract NASW-4005)
(NASA-TM-88446; NAS 1.15:88446; OA-9/5007-AYD; DERAT-9/5007-DY) Avail: NTIS HC A03/MF A01 CSCL 14B

The design of a cryogenic wind tunnel which operates continuously, and is capable of attaining transonic speeds at generating pressures of about 3 bars is described. Its stainless steel construction with inside insulation allows for very rapid temperature variations promoted by rapid changes in the liquid nitrogen flow. A comparative study of temperature measuring probes shows a good reliability of thin sheet thermocouples. To measure fluctuations, only a cold wire makes it possible to record frequencies of about 300 Hz. The use of an integral computer method makes it possible to determine the impact of the wall temperature ratio to the adiabatic wall temperature for the various parameters characterizing the boundary layer. These cases are processed with positive and negative pressure gradients. Author

N86-28102# Department of the Navy, Washington, D. C.
AIRCRAFT BARRICADE Patent
P. R. DIGIOVANNIANTONIO, inventor (to Navy) and W. J. ZIMMER, inventor (to Navy) 28 Jan. 1986 4 p Supersedes AD-D011316
(AD-D012194; US-PATENT-4,566,658; US-PATENT-APPL-SN-519421; US-PATENT-CLASS-244-110)
Avail: US Patent and Trademark Office CSCL 01E

A webbing system is disclosed for use as an aircraft barricade wherein a plurality of rectangularly-shaped engaging loops are arranged in an alternating, multi-planar array and suspended across a landing area in the path of an approaching aircraft upon an assembly of support loops stretched between a pair of stanchions and connected on either side to an energy absorbing device. Slidably connected along upper and lower horizontal components of the support loops, the engaging loops are free to move laterally along the support loops toward the longitudinal axis of the aircraft when penetrated by the fuselage so that the aircraft is ensnared about its wings by the loops with equalized loading and its forward motion arrested. GRA

N86-28961*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
INTERFACE OF THE TRANSPORT SYSTEMS RESEARCH VEHICLE MONOCHROME DISPLAY SYSTEM TO THE DIGITAL AUTONOMOUS TERMINAL ACCESS COMMUNICATION DATA BUS
W. C. EASLEY and J. S. TANGUY (PRC Kentron, Inc., Hampton, Va.) May 1986 34 p refs
(NASA-TM-87728; NAS 1.15:87728) Avail: NTIS HC A03/MF A01 CSCL 14B

An upgrade of the transport systems research vehicle (TSRV) experimental flight system retained the original monochrome display system. The original host computer was replaced with a Norden 11/70, a new digital autonomous terminal access communication (DATAC) data bus was installed for data transfer between display system and host, while a new data interface method was required.

The new display data interface uses four split phase bipolar (SPBP) serial busses. The DATAC bus uses a shared interface ram (SIR) for intermediate storage of its data transfer. A display interface unit (DIU) was designed and configured to read from and write to the SIR to properly convert the data from parallel to SPBP serial and vice versa. It is found that separation of data for use by each SPBP bus and synchronization of data tranfer throughout the entire experimental flight system are major problems which require solution in DIU design. The techniques used to accomplish these new data interface requirements are described. Author

N86-28962# Royal Aircraft Establishment, Farnborough (England).

A NUMERICAL STUDY OF THE AERODYNAMIC INTERFERENCE OF A MODEL SUPPORT SYSTEM USED IN THE RAE 5 METRE WIND TUNNEL

B. C. HARDY 5 Sep. 1985 30 p

(AD-A165671; RAE-TM-AERO-2046; BR97527; ESA-86-97105)

Avail: NTIS HC A03/MF A01

Lift interference effects of under-wing strut guards were studied using panel methods. Unexpected reduction in interference with increase in lift beyond a certain value is accounted for by a sweep dependent, nonlinear lift contribution. The level of agreement between theory and experiment shows that the mutual lift and the displacement effects need to be considered. Further comparisons between the calculation method and experiment are necessary to establish how much of the remaining discrepancy in calculations is due to the shortcomings of the method and how much to uncertainties in the experimental data. ESA

N86-28963# Resource International, Inc., Columbus, Ohio.

MECHANISTIC METHODOLOGY FOR AIRPORT PAVEMENT DESIGN WITH ENGINEERING FABRICS. VOLUME 2: ADVANCED CONCEPTS, VALIDATION AND CRITERIA Final Report

K. MAJIDZADEH, G. J. ILVES, and V. R. KUMAR 7 May 1986 95 p

(Contract DTFA01-81-C-10043)

(DOT/FAA/PM-84/9,II-VOL-2) Avail: NTIS HC A05/MF A01

This report is Volume 2 of a two volume set dealing with the application of non-woven fabrics to rigid airport pavements to control and/or retard the development of reflection cracking of flexible overlays due to both thermal stresses and load-associated fatigue. This volume describes the development of a new viscoelastic analysis model for the analysis of thermal cracking that utilizes fundamental material properties and does not rely on phenomenological distress functions. The methods developed in this work as well as those presented in Phase 1 (Volume 1), have been validated on one airport and four highway projects. The validation is described in this report and shows that the developed analysis models predict the reflection cracking phenomenon for all projects very well. This report also describes the laboratory evaluation of a fiber-asphalt SAMI layer that shows promise for use in reflection cracking control. Finally, specifications for material properties, testing procedures, and construction methods are presented. Author

N86-28964*# National Aeronautics and Space Administration, Washington, D.C.

TESTS WITH THREE-DIMENSIONAL ADJUSTMENTS IN THE RECTANGULAR WORKING SECTION OF THE FRENCH T2 WIND TUNNEL WITH AN AS 07-TYPE SWEPT-BACK WING MODEL

A. BLANCHARD, M. J. PAYRY, and J. F. BREIL Jul. 1986 161 p Transl. into ENGLISH of "Essais d'Adaptation Tridimensionnelle de la Veine Rectangulaire de la Soufflerie T2 en Presence d'une Maquette d'Aile en Fleche du Type AS 07" rept. OA-34/3075, DERAT-12/5015-DN ONERA, France, Nov. 1985 p 1-24 Transl. by The Corporate Word, Inc., Pittsburgh, Pa.

(Contract NASW-4006)

(NASA-TM-88442; NAS 1.15:88442; OA-34/3075; DERAT-12/5015-DN) Avail: NTIS HC A08/MF A01 CSCL 14B

The results obtained on the AS 07 wing and the working section walls for three types of configurations are reported. The first, called non-adapted, corresponds to the divergent upper and lower rectilinear walls which compensate for limit layer thickening. It can serve as a basis for complete flow calculations. The second configuration corresponds to wall shapes determined from calculations which tend to minimize interference at the level of the fuselage. Finally, the third configuration, called two-dimensional adaptation, uses the standard method for T2 profile tests. This case was tested to determine the influence of wall shape and error magnitude. These results are not sufficient to validate the three-dimensional adaptation; they must be coordinated with calculations or with unlimited atmosphere tests. Author

N86-28969# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Goettingen (West Germany). Inst. fuer Experimentelle Stroemungsmechanik.

THE EFFECT OF A SPLITTER PLATE AS BOUNDARY LAYER REMOVAL SYSTEM IN HALF-MODEL TESTING

H. BIPPES Sep. 1985 29 p

(DFVLR-FB-85-64; ISSN-0171-1342; ESA-86-97454) Avail: NTIS HC A03/MF A01; DFVLR, Cologne, West Germany, DM 10.50

The effect of a splitter plate as boundary layer removal system in half-model testing is investigated. The experiments are performed on a rectangular wing in the range of maximum lift in subsonic flow. Oil flow patterns display the footprints of a complicated three-dimensional secondary flow in the neighborhood of the model to wall junction. This secondary flow leads to a considerable increase of local lift. The data analysis reveals that its intensity depends on the vorticity of the free shear layer separating from the suction side of the wing and the spanwise variation of the circulation, but only slightly on the thickness of the boundary layer on the splitter plate. Comparison with tests without splitter plate shows that under the test conditions investigated the use of the splitter plate is not an effective means for improving the mirror conditions in half-model testing. ESA

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ASTRONAUTICS

Includes astronautics (general); astrodynamics; ground support systems and facilities (space); launch vehicles and space vehicles; space transportation; spacecraft communications, command and tracking; spacecraft design, testing and performance; spacecraft instrumentation; and spacecraft propulsion and power.

A86-40515* Alabama Univ., Huntsville.
AN ORBITAL MANEUVERING VEHICLE SIMULATOR
W. TEOH, J. WALLS (Alabama, University, Huntsville), T. BRYAN, F. ROE (NASA, Marshall Space Flight Center, Huntsville, AL), and N. SHIELDS (Essex Corp., Huntsville, AL) IN: Space tech; Proceedings of the Conference and Exposition, Anaheim, CA, September 23-25, 1985 . Dearborn, MI, Society of Manufacturing Engineers, 1985, p. 6-14 to 6-23.

The Orbital Maneuvering Vehicle (OMV) is a teleoperated vehicle designed to dock with a target vehicle in space to peform certain tasks. This vehicle is not yet in production, but a simulator of the OMV is located at Marshall Space Flight Center (MSFC). The MSFC facility provides a realistic simulation of the OMV. Various docking maneuvers can be studied in some detail. A special robot has been constructed that provides a moving target for the simulator to dock with. This facility is valuable for conducting studies on the OMV; it also is excellent for personnel training. Author

A86-40581*# Jet Propulsion Lab., California Inst. of Tech., Pasadena.
SYSTEM AND TECHNOLOGY CONSIDERATIONS FOR SPACE-BASED AIR TRAFFIC SURVEILLANCE
A. VAISNYS (California Institute of Technology, Jet Propulsion Laboratory, Pasadena) IN: Space Systems Technology Conference, San Diego, CA, June 9-12, 1986, Technical Papers . New York, American Institute of Aeronautics and Astronautics, 1986, p. 31-36. FAA-sponsored research.
(AIAA PAPER 86-1170)

This paper describes the system trade-offs examined in a recent study of space-based air traffic surveillance. Three system options, each satisfying a set of different constraints, were considered. The main difference in the technology needed to implement the three systems was determined to be the size of the spacecraft antenna aperture. It was found that essentially equivalent position location accuracy could be achieved with apertures from 50 meters down to less than a meter in diameter, depending on the choice of signal structure and on the desired user update rate. Author

A86-40612*# Lockheed-California Co., Burbank.
DEVELOPMENT OF A REUSABLE, FLIGHT-WEIGHT CRYOGENIC FOAM INSULATION SYSTEM
P. S. MCAULIFFE (Lockheed-California Co., Burbank), R. C. DAVIS, and A. H. TAYLOR (NASA, Langley Research Center, Hampton, VA) AIAA, Space Systems Technology Conference, San Diego, CA, June 9-12, 1986. 11 p. refs
(AIAA PAPER 86-1189)

Attention is given to a light weight foam insulation system applicable to reusable cryogenic propellant tankage for hypersonic aircraft and space launch vehicles. The insulation system consists of nominally sized blocks of a high temperature-resistant polymethacrylimide foam that is wrapped with a vapor-impermeable membrane of Kapton-aluminum-Kapton laminate, which is adhesively bonded to the outer propellant tank wall. Test results are presented which indicate that this insulation system is capable of enduring a Mach 5 service environment without structural cracking, deterioration, or loss of performance. O.C.

A86-41274
MASTERING THE TRANSATMOSPHERE
J. W. CANAN Air Force Magazine (ISSN 0730-6784), vol. 69, June 1986, p. 48-54.

The National Aerospace Plane (NASP) program has been organized at Wright-Patterson Air Force Base in order to develop the technologies that can in due course be integrated into a family of highly versatile transatmospheric, hypersonic cruise/orbital speed manned craft. In addition to serving as satellite launchers, NASP vehicles could be employed in such missions as reconnaissance, global interdiction, and interception of attacking space forces. NASP transatmospheric vehicles are expected to require far less logistical support than the current Space Shuttles, and could be launched on short notice from dispersed and accessible runways. The earliest operational date expected for a NASP craft is, however, 1995. O.C.

A86-42938*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
FAILURE DETECTION AND ACCOMMODATION IN STRUCTURAL DYNAMICS SYSTEMS USING ANALYTIC REDUNDANCY
J. P. WILLIAMS and R. C. MONTGOMERY (NASA, Langley Research Center, Hampton, VA) IN: Conference on Decision and Control, 24th, Fort Lauderdale, FL, December 11-13, 1985, Proceedings. Volume 2 . New York, Institute of Electrical and Electronics Engineers, Inc., 1985, p. 906-910. refs

The concept of analytic redundancy is extended to identify nonzero constant output failures in large spacecraft active control sensors and actuators, using a set of distributed sensors which do not nominally produce equivalent signals but are related through the structural dynamics of the system. The suboptimal technique uses a Sequential Probability Ratio Test on the residual sequence of a Kalman filter based on a modal structure model, to determine failure of a component based on an assumed failure hypothesis. The specific failure is identified and then the Kalman filter gains are reconfigured for the identified remaining working sensor set. Experimental data using an apparatus whose dynamics are representative of a large spacecraft show the nominal filter performance under failed and unfailed conditions. R.R.

N86-28239# Georgia Inst. of Tech., Atlanta. School of Aerospace Engineering.
FLAME DRIVING OF LONGITUDINAL INSTABILITIES IN DUMP TYPE RAMJET COMBUSTORS
U. G. HEDGE, D. REUTER, B. R. DANIEL, and B. T. ZINN *In* Johns Hopkins Univ. The 22nd JANNAF Combustion Meeting, Vol. 1 p 307-316 Oct. 1985 Previously announced in IAA as A86-19839
(Contract N00014-84-K-0470)
Avail: CPIA, Laurel, Md. 20707 HC $70.00 CSCL 21B

Coaxial, dump type ramjet combustors are often prone to combustion instability problems that can seriously affect their performance. Low frequency instabilities which represent one of the most common types of instabilities encountered are discussed. In particular, the coupling between cone-like flames often encountered in dump type combustors and longitudinal acoustic fields is studied. A variety of experimental techniques, including high speed Schlieren and shadow photography, CH radiation emission and acoustic pressure measurements are used. A strong coupling between the flame response and certain acoustic natural frequencies of the experimental set up is observed. These observations shed new light on flame/acoustic mode interactions in a ramjet combustor-like environment and the limitations of current state of the art theoretical models of this phenomenon. Author

N86-28240# California Inst. of Tech., Pasadena.
NONLINEAR ANALYSIS OF PRESSURE OSCILLATIONS IN RAMJET ENGINES
V. YANG and F. E. C. CULICK *In* Johns Hopkins Univ. The 22nd JANNAF Combustion Meeting, Vol. 1 p 317-329 Oct. 1985
(Contract N00014-84-K-0434)
Avail: CPIA, Laurel, Md. 20707 HC $70.00 CSCL 21B

Pressure oscillations in ramjet engines have been studied using an approximate method which treats the flow fields in the inlet and the combustor separately. The acoustic fields in the combustor are expressed as syntheses of coupled nonlinear oscillators corresponding to the acoustic modes of the chamber. The influences of the inlet flow appear in the admittance function at the inlet/combustor interface, providing the necessary boundary condition for calculation of the combustor flow. A general framework dealing with nonlinear multi-degree-of-freedom system has also been constructed to study the time evolution of each mode. Both linear and nonlinear stabilities are treated. The results obtained serve as a basis for investigating the existence and stabilities of limit cycles for acoustic modes. As a specific example, the analysis is applied to a problem of nonlinear transverse oscillations in ramjet engines. Author

N86-28241# Flow Research, Inc., Kent, Wash.
LARGE EDDY SIMULATIONS OF FLOW IN A RAMJET COMBUSTOR
W. H. JOU and S. MENON *In* Johns Hopkins Univ. The 22nd JANNAF Combustion Meeting, Vol. 1 p 331-339 Oct. 1985
(Contract N00014-84-C-0359)
Avail: CPIA, Laurel, Md. 20707 HC $70.00 CSCL 21B

Cold flow simulations are performed for the flow inside a ramjet combustor with dump. The objective is to develop a numerical simulation code that can be used to study the complex interaction between acoustic waves and large vortex structures in such a device. The compressible Navier-Stokes equations are solved using a MacCormack semi-implicit scheme. Beginning with a flow at rest, the flow seems to reach a state of stationary variation ten longitudinal acoustic cycles after the exit pressure is lowered to a prescribed value. Vorticity contour plots reveal that the shear layer behind the backward-facing step rolls up into large vortices. These vortices go through two pairings before being convected into the wall layer. The frequency of the vortex after the second pairing is near the range of the jet preferred mode. The unsteady component of the dilation field is chosen as a quantity that characterizes the acoustic component of the motion. Contour plots of the dilation field show that it is dominated by the quadrupole sources associated with rolled up vortices. The long-wavelength standing waves cannot be detected using this method. Examination of the two-point, two-time correlation of the pressure variations at several points in the flow field gives evidence that the long-wavelength acoustic waves close to the jet preferred mode frequency have been excited. Author

N86-28242# Naval Research Lab., Washington, D. C. Lab. for Computational Physics.
ACOUSTIC-VORTEX INTERACTIONS IN AN IDEALIZED RAMJET COMBUSTOR
K. KAILASANATH, J. GARDNER, J. BORIS, and E. ORAN *In* Johns Hopkins Univ. The 22nd JANNAF Combustion Meeting, Vol. 1 p 341-350 Oct. 1985
Avail: CPIA, Laurel, Md. 20707 HC $70.00 CSCL 21B

Results are presented of numerical simulations performed to isolate and study the interaction between acoustic waves and large scale coherent vortex structures in an idealized ramjet combustor. A strong coupling between the acoustic modes of the chamber and large scale vortical structures is observed. The results in the early part of the calculations are indicative of an unforced natural vortex growth at a frequency close to the acoustic frequency. With time, the acoustic modes shift the frequency of the most amplified mode into resonance with the acoustic mode. The location in space where the modes grow can also be shifted by acoustic forcing. An interesting new feature that is observed is a low frequency mode corresponding to the passage of the vortex structures through the choked exit. This results in a major alteration of the merging pattern of the vortices. Author

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CHEMISTRY AND MATERIALS

Includes chemistry and materials (general); composite materials; inorganic and physical chemistry; metallic materials; nonmetallic materials; and propellants and fuels.

A86-40251
ALUMINIUM-LITHIUM ALLOYS III; PROCEEDINGS OF THE THIRD INTERNATIONAL ALUMINIUM-LITHIUM CONFERENCE, OXFORD UNIVERSITY, ENGLAND, JULY 8-11, 1985
C. BAKER, ED. (Alcan International, Ltd., Banbury, England), P. J. GREGSON, ED. (Southampton, University, England), S. J. HARRIS, ED. (Nottingham University, England), and C. J. PEEL, ED. (Royal Aircraft Establishment, Farnborough, England) Conference organized and sponsored by the Institute of Metals. London, Institute of Metals, 1986, 640 p. For individual items see A86-40252 to A86-40315.

The papers presented in this volume focus on the fundamental metallurgy, production and processing aspects, and aerospace applications of Al-Li alloys. Emphasis is placed on mechanical properties and fabrication parameters in comparison with the existing aerospace alloys as well as requirements and specific applications of the alloys in airframes and engines in fixed-wing aircraft and helicopters. Papers are included on the production of aluminum-lithium alloys with high specific properties, fatigue crack propagation in mechanically alloyed Al-Li-Mg alloys, superplastic aluminum-lithium alloys, fundamental aspects of hardening in Al-Li and Al-Li-Cu alloys, and mechanical properties of Al-Li-Zn-Mg alloys. V.L.

A86-40252
OVERVIEW
D. LITTLE (Airbus Industrie, Blagnac, France) IN: Aluminium-lithium alloys III; Proceedings of the Third International Aluminium-Lithium Conference, Oxford, England, July 8-11, 1985 . London, Institute of Metals, 1986, p. 15-21.

The role of new metallic and nonmetallic composite materials in reducing the weight and increasing the payload capabilities of aircraft is examined, with particular attention given to aluminum-lithium alloys. A four-step program conducted at the Airbus Industrie, France, with the aim of introducing aluminum-lithium alloys progressively into all aircraft is reviewed. The program includes (1) substitution of Al-Li alloys for conventional alloys in noncritical parts; (2) substitution of Al-Li alloys in non-fatigue-critical parts; (3) substitution of Al-Li alloys for current alloys in fatigue-critical structures; and (4) new design solutions to make optimum use of Al-Li alloy properties. V.L.

A86-40255
PRODUCTION OF ALUMINIUM-LITHIUM ALLOY WITH HIGH SPECIFIC PROPERTIES
P. MEYER and B. DUBOST (Cegedur Pechiney, Centre de Recherches et Developpement, Voreppe, France) IN: Aluminium-lithium alloys III; Proceedings of the Third International Aluminium-Lithium Conference, Oxford, England, July 8-11, 1985 . London, Institute of Metals, 1986, p. 37-46. refs

Reducing the weight of aircraft structure through the use of lighter advanced materials has become a major goal. Pechiney's extensive research and development program has resulted in a new family of aluminum-lithium alloys. Thanks to the combination of efficient D.C. casting, alloy design coprecipitation strengthening and structural control, these CP 27X alloys overcome the previously identified brittleness of Al-Li alloys and already match most current goals for a wide use on aircraft. Author

A86-40256
'ALITHALITE' ALLOYS - PROGRESS, PRODUCTS AND PROPERTIES
P. E. BRETZ and R. R. SAWTELL (Alcoa Laboratories, Alcoa Center, PA) IN: Aluminium-lithium alloys III; Proceedings of the Third International Aluminium-Lithium Conference, Oxford, England, July 8-11, 1985 . London, Institute of Metals, 1986, p. 47-56. refs

Alithalite Al-Li alloys are being developed by Alcoa to meet four first-generation objectives: low-density replacements for 2024-T3X, 7075-T6X, and 7075-T73X products and a moderate-strength, minimum density alloy. One alloy, recently registered as 2090 (Al-2.7 wt pct Cu-2.2 pct Li-0.12 pct Zr), has been introduced as a replacement for 7075-T6X plate, sheet, and extrusion product forms. This paper concentrates on discussing the metallurgical and engineering property characteristics of this alloy. Progress toward developing alloys to meet the other objectives also will be outlined, with emphasis given to property achievements. Author

A86-40267
ADHESIVE BONDING OF ALUMINIUM-LITHIUM ALLOYS
D. J. ARROWSMITH, R. J. DAVIES (Aston, University, Birmingham, England), A. W. CLIFFORD, and D. A. MOTH (Admiralty Research Establishment, Portland, England) IN: Aluminium-lithium alloys III; Proceedings of the Third International Aluminium-Lithium Conference, Oxford, England, July 8-11, 1985 . London, Institute of Metals, 1986, p. 148-151. refs

Al-2.35 pct Li-1.13 pct Cu alloy was adhesively bonded using established chromic acid anodizing and phosphoric acid anodizing processes. A new process consisting of sulfuric acid anodizing followed by a phosphoric acid dip was also used. The initial bond strengths and durabilities of lap shear joints of aluminum-lithium and aluminum-magnesium alloys were found to be similar. The anodizing characteristics of aluminum-lithium and aluminum-magnesium alloys were also found to be similar. Author

A86-40280
COMPARISON OF CORROSION BEHAVIOUR OF LITHIUM-CONTAINING ALUMINIUM ALLOYS AND CONVENTIONAL AEROSPACE ALLOYS
P. L. LANE, J. A. GRAY, and C. J. E. SMITH (Royal Aircraft Establishment, Materials and Structures Dept., Farnborough, England) IN: Aluminium-lithium alloys III; Proceedings of the Third International Aluminium-Lithium Conference, Oxford, England, July 8-11, 1985 . London, Institute of Metals, 1986, p. 273-281. refs

Marine exposure and accelerated laboratory corrosion tests have been used to compare the corrosion behavior of some Al-Li-Mg-Cu alloys with conventional aerospace alloys. The pitting resistance of Al-Li-Mg-Cu alloys in neutral salt fog and under total immersion conditions is superior to that of conventional alloys. In a marine environment, Al-Li-Mg-Cu alloys exhibit exfoliation corrosion; the sheet material is particularly susceptible and resistance to exfoliation is improved by overaging. Stress corrosion cracking properties are similar to conventional alloys. Al-Li-Mg-Cu alloys are galvanically compatible with other aluminum alloys. Author

A86-40291
TEXTURES DEVELOPED IN AL-LI-CU-MG ALLOY
M. J. BULL and D. J. LLOYD (Alcan International, Ltd., Kingston, Canada) IN: Aluminium-lithium alloys III; Proceedings of the Third International Aluminium-Lithium Conference, Oxford, England, July 8-11, 1985 . London, Institute of Metals, 1986, p. 402-410. refs

The crystallographic texture development of alloy 8090 as a function of rolling (hot and cold), cross-rolling (hot and cold) and after various thermal treatments is discussed. Where applicable, comparison will be made with other high strength aluminium alloys subjected to similar thermo-mechanical treatments. Author

A86-40303
COARSENING OF DELTA PRIME, T1, S PRIME PHASES AND MECHANICAL PROPERTIES OF TWO AL-LI-CU-MG ALLOYS
M. AHMAD and T. ERICSSON (Linkoping Institute of Technology, Sweden) IN: Aluminium-lithium alloys III; Proceedings of the Third International Aluminium-Lithium Conference, Oxford, England, July 8-11, 1985 . London, Institute of Metals, 1986, p. 509-515. Research supported by the Styrelsen for Teknisk Utveckling and Saab-Scania, AB. refs

The aging response of the alloy has been determined by hardness measurements. The microstructures developed after various artificial aging treatments were studied by TEM. The effect of prestretch on the precipitation of S prime and T1 was investigated. The density of S prime and T1 was increased due to the prestretch. A significant improvement in the yield strength was obtained by stretching prior to aging. The ultimate tensile strength was also slightly improved, while the elongation to fracture was slightly reduced. In the under-aged condition deformation was localized within slip bands. The deformation was homogeneous for peak aged conditions. The fracture surfaces of failed tensile specimens were studied with the help of scanning electron microscopy (SEM). The mechanical properties and fracture behavior of the alloy has been correlated with microstructural features. Author

A86-40304
DEVELOPMENT OF PROPERTIES WITHIN HIGH-STRENGTH ALUMINIUM-LITHIUM ALLOYS
P. J. GREGSON (Southampton, University, England), C. J. PEEL, and B. EVANS (Royal Aircraft Establishment, Materials and Structures Dept., Farnborough, England) IN: Aluminium-lithium alloys III; Proceedings of the Third International Aluminium-Lithium Conference, Oxford, England, July 8-11, 1985 . London, Institute of Metals, 1986, p. 516-523. refs

Further additions of magnesium and/or copper to Lital 'A' are shown to lead to high strengths satisfying DTD XXXB requirements; the extent of these additions is limited by the homogenization process. Optimum properties in the unstretched sheet are associated with the coprecipitation of delta prime and S phase. Author

A86-40305
AGE HARDENING BEHAVIOR OF DTD XXXA
K. WELPMANN, M. PETERS (DFVLR, Institut fuer Werkstoff-Forschung, Cologne, West Germany), and T. H. SANDERS, JR. (Purdue University, West Lafayette, IN) IN: Aluminium-lithium alloys III; Proceedings of the Third International Aluminium-Lithium Conference, Oxford, England, July 8-11, 1985 London, Institute of Metals, 1986, p. 524-529. refs

Results of a study of the artificial and natural aging behavior of DTD XXXA, an Al-Li alloy considered for applications in the next generation military and transport aircraft, are reported. During natural aging, a strength increase is observed after an incubation period of about 30 hr, which is attributed to the formation and growth of Guinier-Preston zones. The artificial age hardening curves in the range 150-185 C have a plateau before reaching a peak; the plateau coincides with a minimum in elongation. The yield stress increases beyond the plateau and the corresponding increase of the elongation are attributed to an accelerated growth of S-prime particles. Stretching before artificial aging leads to a higher strength, which is thought to be a result of a more homogeneous distribution of the S-prime phase. V.L.

A86-40306
EFFECT OF PRECIPITATION ON MECHANICAL PROPERTIES OF AL-LI-CU-MG-ZR ALLOY
J. WHITE, W. S. MILLER, I. G. PALMER (Alcan International, Ltd., Banbury, England), R. DAVIS, and T. S. SAINI (Alcan International, Ltd., Gerrards Cross, England) IN: Aluminium-lithium alloys III; Proceedings of the Third International Aluminium-Lithium Conference, Oxford, England, July 8-11, 1985 . London, Institute of Metals, 1986, p. 530-538. refs

Low ductility and poor fracture toughness in binary Al-Li alloys have been attributed to intense coplanar slip associated with the precipitation of the coherent delta prime phase. The introduction of additional precipitation may disperse planar slip and hence result in an improvement in the relationship between strength, ductility, and fracture toughness in more complex alloys. One such alloy system currently under development is Al-Li-Cu-Mg-Zr where S prime and T1 phases have been observed to nucleate heterogeneously on dislocations and subgrain boundaries. The present work examines the effect of cold work prior to aging at 190 C on the mechanical properties of commercially produced Al-Li-Cu-Mg-Zr sheet. Author

A86-40312
DEFORMATION AND FRACTURE IN AL-LI BASE ALLOYS
W. S. MILLER, M. P. THOMAS (Alcan International, Ltd., Banbury, England), D. J. LLOYD, and D. CREBER (Alcan International, Ltd., Kingston, Canada) IN: Aluminium-lithium alloys III; Proceedings of the Third International Aluminium-Lithium Conference, Oxford, England, July 8-11, 1985 . London, Institute of Metals, 1986, p. 584-594. refs

The deformation structures observed in Al-Li and Al-Li-Cu-Mg-Zr alloys are investigated with a view to determining the causes of the low ductility and fracture toughness of Al-Li-based alloys. An analysis of results, obtained by in-situ fracture surface analysis techniques, indicates that the low ductility and toughness of Al-Li alloys is largely due to grain-boundary segregation. Ways of reducing the effect of grain-boundary segregation on fracture behavior are discussed. V.L.

A86-40345
EFFECT OF MOISTURE ON THERMAL PROPERTIES OF COMPOSITE MATERIALS FOR AEROSPACE APPLICATIONS
M. MARCHETTI, G. MAURA (Roma I, Universita, Rome, Italy), M. PAURI (Ancona, Universita, Italy), and F. VENIALI (Roma II, Universita, Rome, Italy) IN: Developments in the science and technology of composite materials; Proceedings of the First European Conference on Composite Materials and Exhibition, Bordeaux, France, September 24-27, 1985 . Bordeaux, France, Association Europeenne des Materiaux Composites, 1985, p. 201-206. Research sponsored by the Ministero della Pubblica Istruzione. refs

The effects of the fiber characteristics, water absorption and thermal spikes on the porosity and variations in the glass transition temperature (Tg) of composite materials were examined experimentally. Samples of fiber glass reinforced materials, carbon fiber reinforced plastic and Kevlar fiber reinforced laminates were exposed on two sides to water vapor. The samples were withdrawn at specified intervals and weighed. Equivalent specimens were subjected to thermal spikes ranging from 20-120 deg lasting for 5 min for seven times each. Other samples were degassed and sealed in containers before being exposed to the thermal spikes. Porosity did not change with the thermal spikes, which are typical of conditions experienced by materials on spacecraft and high performance aircraft. The apparent Tg values of epoxy matrices fell with water vapor absorption. Exposure to thermal spikes inhibited recovery from water vapor absorption, while recovery did occur in samples which absorbed moisture at room temperature. M.S.K.

A86-40364
CARBON-CARBON COMPOSITES FOR BRAKING [LES CARBONE-CARBONE POUR LE FREINAGE]
L. HERAUD and B. BROQUERE (SocieteEuropeenne de Propulsion, Saint-Medard-en-Jalles, France) IN: Developments in the science and technology of composite materials; Proceedings of the First European Conference on Composite Materials and Exhibition, Bordeaux, France, September 24-27, 1985 . Bordeaux, France, Association Europeenne des Materiaux Composites, 1985, p. 440-446. In French. refs

The first use of Carbon-carbon composites (CCC) brake components in aircraft was on the Concorde, realizing a weight savings of 600 kg. CCC brakes are now used on the Mirage 2000 and on the Airbus 300 series aircraft. Brakes are intended to absorb and dissipate, by thermal emission, the kinetic energy of a moving vehicle. The thermal mass and specific mass of CCC are higher and lower than those of steel and coopper, respectively. Furthermore, thermomechanical properties of CCC do not degrade at high temperatures. CCC has a coefficient of friction of 0.3-0.6, similar to other braking materials, and remains stable under prolonged braking. Recent experience and expanded production of CCC materials have been sufficient to make the cost of CCC brakes competitive with other materials. The success of CCC brakes in aircraft and formula 1 racing cars is expected to lead to a widespread adoption of CCC brakes in cars. M.S.K.

A86-40487
CARBON FIBRES AND THEIR COMPOSITES
E. FITZER, ED. (Karlsruhe, Universitaet, West Germany) Berlin and New York, Springer-Verlag, 1985, 307 p. For individual items see A86-40488 to A86-40499.

The present conference considers topics encompassing the fields of advanced composite reinforcing fibers, polymeric matrices, fabrication and design methodologies for carbon fiber-reinforced composites (CFRPs), the testing and fracture behavior of CFRPs, CFRP applications in aerospace, and the R&D activities in carbon fiber production of Brazil, India, China, and South Korea. Specific discussions are presented concerning the effect of matrix resin choice on prepreg processing, the development of thermosetting polyimide matrix resins, autoclave compression molding, design preparations for large space structures, CFRP testing and properties optimization, industrial and marine applications of carbon fiber reinforcements, and biomedical applications of CFRP. O.C.

A86-40488
TECHNICAL STATUS AND FUTURE PROSPECTS OF CARBON FIBRES AND THEIR APPLICATION IN COMPOSITES WITH POLYMER MATRIX (CFRPS)
E. FITZER (Karlsruhe, Universitaet, West Germany) IN: Carbon fibres and their composites . Berlin and New York, Springer-Verlag, 1985, p. 3-45. refs

The structure of carbon fibres and its dependence on the presursor material gives an understanding of the properties of today's commercial fibre types. The possibilities of further improvement are considered from theoretical viewpoint as well as starting from the properties of PAN based fibres of the new generation must in development. The problem of correct terminology of this promising new material is raised. Economic considerations are presented, comprising a review on present technology, the world demand and the price situation. Finally, the various fields for application of carbon fibres - such as aerospace, transportation, sport, machinery and apparatus, cryogenic technology, as well as medicine - are discussed briefly. Author

A86-40498
EXPERIENCES IN FRG IN AEROSPACE APPLICATION
K. BRUNSCH (Messerschmitt-Boelkow-Blohm GmbH, Munich, West Germany) IN: Carbon fibres and their composites . Berlin and New York, Springer-Verlag, 1985, p. 206-228.

Attention is given to the experience gained in West Germany to date with CFRPs' fiber, matrix resin, and fiber-resin interface characteristics. Attention is given to space structures applications such as the Intelsat V series satellites' solar cell array structure,

as well as the Tornado fighter aircraft's taileron, a technology development CFRP fighter cockpit, and helicopter rotor blades and driveshafts. Also noted are recent advancements in CFRP fabrication and quality assurance techniques. O.C.

A86-40575
A SIMPLIFIED RESIDUAL STRESS MODEL FOR PREDICTING FATIGUE CRACK GROWTH BEHAVIOR AT COLDWORKED FASTENER HOLES
X. SU, M. GU, and M. YAN (Institute of Aeronautical Materials, Beijing, People's Republic of China) Fatigue and Fracture of Engineering Materials and Structures (ISSN 8756-758X), vol. 9, no. 1, 1986, p. 57-64. refs

This paper presents an investigation of the fatigue crack growth (FCG) behavior at fastener holes in a high strength steel, 30CrMnSiNi2A, before and after a cold-expansion process. The fatigue life of coldworked specimens was significantly increased compared to noncoldworked ones and increased the lower applied stress level. From a study of the residual stress distribution near the edge of the hole, it was found that the experimental residual compressive stresses in absolute values were much less than the calculated values derived by previous analytical methods. Thus, a simplified residual stress model for describing the FCG behavior at coldworked fastener holes is proposed, from which, the Delta-K(eff) and fatigue lives of specimens after cold-expansion can be predicted satisfactorily for engineering applications. Author

A86-40619
STRUCTURAL MATERIALS IN AERONAUTICS. II - PROSPECTS AND PERSPECTIVES
G. G. POPE (Royal Aircraft Establishment, Farnborough, England) Aerospace (UK) (ISSN 0305-0831), vol. 13, May-June 1986, p. 22-30. refs

Materials designed for airframe and gas turbine applications are presented, and it is noted that for the former category, the UK has the following alloys in mind: (1) a medium strength alloy DTDXXXA, intended to replace the medium strength general purpose alloy 2014-T651; (2) a high strength alloy DTDXXXB to replace higher strength 7000 series alloys; and (3) a fatigue resistant alloy DTDXXXC to replace 2024-T351. In the area of gas turbine applications, nickel-based alloys reinforced with tungsten wires have been made as well as ceramic materials such as those derived from the Si-Al-O-N system, and a composite made of carbon fibers in a carbon matrix. It is concluded that both the properties and the cost of an aircraft component are determined as much by the manufacturing route as by the intrinsic properties and cost of the material. Moreover, these areas require continued attention if the major potential benefits (i.e., cost effectiveness) of current advances in materials technology are to be realized to the full. K.K.

A86-41051
COMPOSITE MATERIALS: TESTING AND DESIGN; PROCEEDINGS OF THE SEVENTH CONFERENCE, PHILADELPHIA, PA, APRIL 2-4, 1984
J. M. WHITNEY, ED. (USAF, Wright Aeronautical Laboratories, Wright-Patterson AFB, OH) Conference sponsored by ASTM. Philadelphia, PA, American Society for Testing and Materials , 1986, 466 p. For individual items see A86-41052 to A86-41073.

The present conference on the current development state of composite materials ranges over structures, failure mechanisms, delamination characteristics, strength properties, and analysis and characterization methods. Attention is given to the effects of manufacturing defects and service-induced damage on strength, testing and analysis methods for graphite/epoxy filament-wound composites' fracture toughness, the effect of stress biaxiality on transverse tensile strain-to-failure, the effect of laminate stacking sequence on notch sensitivity, and the effect of impact and fatigue loads on the strength of graphite/epoxy composites. Also considered are delamination-resistant composite concepts, the stimulation of delamination by interlaminar shear, and the tensile strength and modulus of a three-dimensional braided composite. O.C.

A86-41052
BOLTED COMPOSITE REPAIRS SUBJECTED TO BIAXIAL OR SHEAR LOADS
R. E. BOHLMANN, G. D. RENIERI, and B. L. RILEY (McDonnell Aircraft Co; Saint Louis, MO) IN: Composite materials: Testing and design; Proceedings of the Seventh Conference, Philadelphia, PA, April 2-4, 1984 . Philadelphia, PA, American Society for Testing and Materials, 1986, p. 34-47. refs
(Contract N62269-81-C-0297)

The methodology to analyze bolted composite repairs subjected to biaxial or shear loads was developed. The methodology was incorporated into an existing McDonnell Aircraft Company (MCAIR) interactive computer program, BREPAIR, which was initially developed for uniaxial loading. The analysis determines bolt loads while accounting for hole clearances and determines patch and laminate strains for doubly symmetric finite regions where the damage is represented as a circular cutout. The analysis was verified by comparing predicted results to industry-recognized solutions for laminates containing circular holes (unrepaired), and to test results of an unrepaired and repaired shear panel. Results of this investigation verified that the methodology developed was a viable analytical tool for determining bolted repair designs for damaged laminates subjected to biaxial or shear loads. Author

A86-41053
CHARACTERIZATION OF T300/V-378A GRAPHITE/BIS-MALEIMIDE FOR STRUCTURAL APPLICATIONS APPLICATIONS
R. L. RAMKUMAR, G. C. GRIMES, and S. J. KONG (Northrop Corp., Aircraft Div., Hawthorne, CA) IN: Composite materials: Testing and design; Proceedings of the Seventh Conference, Philadelphia, PA, April 2-4, 1984 . Philadelphia, PA, American Society for Testing and Materials, 1986, p. 48-63. Navy-sponsored research. refs

In the present evaluation of T300/V-378A graphite fiber/bismaleimide matrix composites in aircraft structures exposed to service temperatures in the 120-204 C range, the microstructure of cured laminates was examined in order to detect the presence of any process-induced defects, followed by moisture absorption studies and static testing of basic properties. Tests were also conducted on loaded and unloaded hole specimens under room-temperature-dry (RTD) and elevated-temperature-wet (ETW) conditions; impact damage tolerance was tested by measuring hard object impact energy levels. Multibay hat-stiffened flat shear panels were fabricated and subjected to pure-shear static and fatigue tests under RTD and ETW conditions. The data obtained were compared with graphite/epoxy laminate data, which indicated that V-378A bismaleimide is a viable alternative to epoxy matrices in ETW conditions. O.C.

A86-41684
COMPOSITE REPAIR TECHNIQUES EXAMINED
J. H. BRAHNEY Aerospace Engineering (ISSN 0736-2536), vol. 6, May 1986, p. 20-24.

Techniques for repairing composite structure damage caused by surface impact damage, surface thermal blisters, internal voids, and delamination are studied. Visual inspections, tapping tests, ultrasonic inspection systems, and optical micrometers are utilized to locate and identify composite damage. Zone charts which explain the materials to be used in each section of the structure, indicate permissible repairs, and outline repair procedures are employed as the guidelines for damage repair. Various repair techniques such as prepreg or precured patches and epoxy injection are examined; the procedures for patching and the wet-layup process are described. Post-failure analysis using optical and scanning electron microscopy is discussed. I.F.

A86-41685
THERMOPLASTIC COMPOSITES - DESIGN MATERIAL OF THE 1990S?
D. J. HOLT Aerospace Engineering (ISSN 0736-2536), vol. 6, May 1986, p. 36-44.

The characteristics and uses of thermoplastic resins are discussed. The properties of thermoplastic resins are compared to thermoset resins and metals. It is observed that thermoplastic resins soften when heated and harden when cooled, their molecular structure remains linear before and after heating and cooling, they have increased temperature resistance, higher melting points, and are resistant to the solvents, fuels and oils used in the aerospace industry. The thermoplastic resins are manufactured by molding, filament winding, and pultrusion; the use of these techniques to produce aircraft components is examined. The properties of various resins applicable for use in advanced high-performance thermoplastic composites and the aircraft cabin interiors are described. The utilization of high-performance thermoplastic composites in the future ATF and the stealth bomber is proposed. I.F.

A86-41988
INFLUENCE OF MOLYBDENUM, TUNGSTEN, AND COBALT ON THE CORROSION OF HIGH-TEMPERATURE STRENGTH NICKEL ALLOYS IN MOLTEN SALTS
I. V. ORYSHICH and O. S. KOSTYRKO (AN USSR, Institut Problem Lit'ia, Kiev, Ukrainian SSR) (Metallovedenie i Termicheskaia Obrabotka Metallov, Oct. 1985, p. 21-25) Metal Science and Heat Treatment (ISSN 0026-0673), vol. 27, no. 9-10, March 1986, p. 740-746. Translation. refs

Specimens of ZhS6K, EP539, and EP958 high-temperature nickel alloys, which are commonly used in gas turbine, were tested for sulfide and chloride corrosion in molten salts based on sodium sulfate and sodium chloride. It is found that the addition of molybdenum, tungsten, and cobalt increases the resistance of the nickel alloys to sulfide corrosion but decreases their resistance to chloride corrosion. It is also shown that the amounts of molybdenum and tungsten required for maximum resistance to sulfide corrosion depend on the Cr content of the alloys. V.L.

A86-42424
NEW ALLOYS FROM THE QUANTUM ENGINEER
D. PETTIFOR New Scientist (ISSN 0028-6664), vol. 110, May 29, 1986, p. 48-51.

The contribution quantum mechanics is making to the design of aerospace alloys is described. The strength of the intermetallic particles in an Al matrix determines the properties of the alloy as a whole. The goal is to predict which intermetallic compounds will form and their properties. Quantum mechanics, in the form of Schoedinger's equation, allows predicting the structure and mechanical properties of an intermetallic. Recent data have shown that the average number of valence electrons per atom controls the formation of face-centered or body-centered lattices. Other factors are the differences in size and the electronegativity of the combined atoms. Studies have also revealed a dependency of the mechanical properties on the quantum mechanical bond energy and none on the ionic binding energy. Finally, techniques are outlined for using quantum mechanics to predict the properties and existence of ternary phases. M.S.K.

A86-42610*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
EFFECT OF SILANE CONCENTRATION ON THE SUPERSONIC COMBUSTION OF A SILANE/METHANE MIXTURE
G. B. NORTHAM, A. G. MCLAIN, G. L. PELLETT (NASA, Langley Research Center, Hampton, VA), and G. S. DISKIN (Vigyan Research Associates, Inc., Hampton, VA) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 22nd, Huntsville, AL, June 16-18, 1986. 9 p. refs
(AIAA PAPER 86-1396)

A series of direct connect combustor tests was conducted to determine the effect of silane concentration on the supersonic combustion characteristics of silane/methane mixtures. Shock tube ignition delay data indicated more than an order of magnitude reduction in ignition delay times for both 10 and 20 percent silane/methane mixtures as compared to methane. The ignition delay time of the 10 percent mixture was only a factor of 2.3 greater than that of the 20 percent mixture. Supersonic combustion tests were conducted with the fuel injected into a model scramjet combustor. The combustor was mounted at the exit of a Mach 2 nozzle and a hydrogen fired heater was used to provide a variation in test gas total temperature. Tests using the 20 percent silane/methane mixture indicated considerable combustion enhancement when compared to methane alone. This mixture had an autoignition total temperature of 1650 R. This autoignition temperature can be contrasted with 2330 R for hydrogen and 1350 R for a 20 percent silane/hydrogen mixture in similar hardware. Methane without the silane additive did not autoignite in this configuration at total temperatures as high as 3900 R, the maximum temperature at which tests were conducted. Supersonic combustion tests with the silane concentration reduced to 10 percent indicated little improvement in combustion performance over pure methane. The addition of 20 percent silane to methane resulted in a pyrophoric fuel with good supersonic combustion performance. Reducing the silane concentration below this level, however, yielded a less pyrophoric fuel that exhibited poor supersonic combustion performance. Author

A86-42665*# National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.
NEW VISTAS IN THE DETERMINATION OF HYDROGEN IN AEROSPACE ENGINE METAL ALLOYS
M. D. DANFORD (NASA, Marshall Space Flight Center, Huntsville, AL) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 22nd, Huntsville, AL, June 16-18, 1986. 6 p. refs
(AIAA PAPER 86-1479)

The application of diffusion theory to the analysis of hydrogen desorption data has been studied. From these analyses, important information concerning hydrogen solubilities and the nature of the hydrogen distributions in the metal has been obtained. Two nickel base alloys, Rene' 41 and Waspaloy, and one ferrous alloy, 4340 steel, were studied in this work. For the nickel base alloys, it was found that the hydrogen distributions after electrolytic charging conformed closely to those which would be predicted by diffusion theory. The hydrogen distributions in electrolytically charged 4340 steel, on the other hand, were essentially uniform in nature, which would not be predicted by diffusion theory. Finally, it has been found that the hydrogen desorption is completely explained by the nature of the hydrogen distribution in the metal, and that the 'fast' hydrogen is not due to surface and subsurface hydride formation, as was originally proposed. Author

A86-42712*# Material Concepts, Inc., Columbus, Ohio.
ADVANCED ROTARY ENGINE COMPONENTS UTILIZING FIBER REINFORCED MG CASTINGS
D. GODDARD, W. WHITMAN, R. PUMPHREY (Material Concepts, Inc., Columbus, OH), and C.-M. LEE AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 22nd, Huntsville, AL, June 16-18, 1986. 7 p.
(AIAA PAPER 86-1559)

Under a two-phase program sponsored by NASA, the technology for producing advanced rotary engine components utilizing graphite fiber-reinforced magnesium alloy casting is being developed. In Phase I, the successful casting of a simulated intermediate housing was demonstrated. In Phase II, the goal is to produce an operating rotor housing. The effort involves generation of a material property data base, optimization of parameters, and development of wear- and corrosion-resistant cast surfaces and surface coatings. Results to date are described. Author

A86-43134
PROTECTIVE COATING SYSTEMS FOR HIGH-TEMPERATURE GAS TURBINE COMPONENTS; PROCEEDINGS OF THE CONFERENCE, LONDON, ENGLAND, NOVEMBER 13, 14, 1984
Conference sponsored by the Royal Society. Materials Science and Technology (ISSN 0267-0836), vol. 2, March 1986, 144 p. For individual items see A86-43135 to A86-43150.

Papers are presented on pack cementation processes, plasma spray coating processes, physical vapor deposition processes, quality control of high-temperature protective coatings, and the effect of environment on mechanical properties of coated superalloys and gas turbine blades. Also considered are structural stability of coatings, coating-substrate interactions, properties of thermal barrier coatings, laboratory tests for hot-corrosion studies, and correlation between laboratory corrosion rig testing and service experience. Other topics include the use of protective coatings in gas turbine engines, marine applications, coating service experience with industrial gas turbines, and the future direction of research on high-temperature coatings. Papers are also presented on protection against hot corrosion in marine gas turbines, evaluation of additive effects on hot corrosion of Ni-Cr and Co-Cr alloys, and coating/substrate interfaces in Ni-Cr-Al systems. R.R.

A86-43147
USE OF PROTECTIVE COATINGS IN AERO GAS TURBINE ENGINES
G. W. MEETHAM (Rolls-Royce, Ltd., Derby, England) (Royal Society, Conference on Protective Coating Systems for High-Temperature Gas Turbine Components, London, England, Nov. 13, 14, 1984) Materials Science and Technology (ISSN 0267-0836), vol. 2, March 1986, p. 290-294. refs

Protective coatings used in gas turbine engine turbine and combustion sections are reviewed, and coating selection factors for turbine rotor blade applications, service experience, and the influence of the blade operating environment, are discussed. Aluminide coatings, the most widely used, are inadequate in the most extreme temperature, corrosion and mechanical environments, and improved coatings such as MCrAlY and platinum aluminide coats are considered. Increased component life has been found in using thermal barrier coats for combustion liners, and the recent application of thermal barrier coats to stator vane platforms has necessitated the development of improved bond coats and ceramic overlays. Thermal barrier and corrosion resistant coating choice considerations are cost effectiveness and application specificity. R.R.

A86-43329#
COMPOSITE REPAIR AT THE NAVAL AIR REWORK FACILITY, NORTH ISLAND
B. L. HALLOCK (U.S. Navy, Naval Air Rework Facility, San Diego, CA) AIAA and SOLE, Aerospace Maintenance Conference, 2nd, San Antonio, TX, May 21-23, 1986. 8 p. refs
(AIAA PAPER 86-1140)

This paper describes the methodology used to inspect, assess, and repair advanced composite components on Naval aircraft at the Naval Air Rework Facility, North Island. Future considerations for advanced composite repair and maintenance are also addressed. To repair a damaged advanced composite component requires a sequence of events: inspection, assessment, damage removal repair design, repair manufacture, repair installation, and finally repair verification. To date, honeycomb bonded advanced composite skins and monolithic skins have been repaired by the Rework Facility. The advanced composite repair program is expanding as more composite structured aircraft enter the fleet. As new development within the composite field lead to new applications, maintenance/supportability should be a major consideration. Well planned support is an essential part to the success of an aircraft program. Author

A86-43420
EFFECT OF DIFFERENT HYDROGEN-INJECTION TECHNIQUES ON ITS BURNUP IN A SUPERSONIC AIR FLOW [VLIIANIE RAZLICHNYKH SPOSOBOV PODACHI VODORODA NA EGO VYGORANIE V SVERKHZVUKOVOM POTOKE VOZDUKHA]
V. A. ZABAIKIN and A. M. LAZAREV (AN SSSR, Institut Teoreticheskoi i Prikladnoi Mekhaniki, Novosibirsk, USSR) Akademiia Nauk SSSR, Sibirskoe Otdelenie, Izvestiia, Seriia Tekhnicheskie Nauki (ISSN 0002-3434), March 1986, p. 44-49. In Russian. refs

The technique used to inject a gaseous fuel into a supersonic oxidizer flow has an important effect on flow pressure losses, flame stabilization, and combustion efficiency during supersonic combustion. In the present study, an experiment was conducted to measure hydrogen combustion efficiency for different injection techniques at a temperature of the supersonic air flow above 1000 K. Three types of injectors were considered: straight-flow, vortex-type, and a device yielding a fan of perpendicular jets. The data confirm the decisive role of the injection method and the wave structure of the jets on combustion efficiency in a hydrogen flame. B.J.

N86-28131* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
LIGHT WEIGHT FIRE RESISTANT GRAPHITE COMPOSITES Patent
D. A. KOURTIDES, J. A. PARKER, and M. T. S. HSU 1 Jul. 1986 12 p Filed 28 Feb. 1985 Supersedes N85-28976 (23 - 18, p 3068)
(NASA-CLASS-ARC-11615-1SB; US-PATENT-4,598,007; US-PATENT-APPL-SN-706682; US-PATENT-CLASS-428-116; US-PATENT-CLASS-428-408; US-PATENT-CLASS-428-921; US-PATENT-CLASS-526-265) Avail: US Patent and Trademark Office CSCL 11D

Composite structures with a honeycomb core and characterized by lightweight and excellent fire resistance are provided. These sandwich structures employ facesheets made up of bismaleimide-vinyl styrylpyridine copolymers with fiber reinforcement such as carbon fiber reinforcement. In preferred embodiments the facesheets are over layered with a decorative film. The properties of these composites make them attractive materials of construction aircraft and spacecraft. NASA

N86-28133# Construcciones Aeronauticas S.A., Madrid (Spain).
CHEMICAL CONTROL FOR AIRBUS COMPOSITES. HPLC STANDARDIZATION
J. SANCHEZ and E. GARATE 20 Dec. 1984 141 p
(I-104/84; ESA-86-97060) Avail: NTIS HC A07/MF A01

Liquid chromatography with a UV detector to assess resins used in the Airbus was tested on two resins. Results show that the chromatographic method permits an adequate separation of the different components of both resins, though the fact of having to perform a gradient limits the integration accuracy of the different peaks and therefore supposes a limitation of the method. None of the two wavelengths used (220 and 230 nm) seems to have any influence on the accuracy of the results obtained. ESA

N86-28168# Avco-Everett Research Lab., Mass.
LASER METALWORKING TECHNOLOGY TRANSFER Final Report
O. A. SANDVEN 1986 84 p
(Contract N00014-82-C-2373)
(AD-A165808) Avail: NTIS HC A05/MF A01 CSCL 11F

The Technology Transfer program assists in the utilization and integration of the laser facility in the manufacturing of naval ordnance components and systems. This assistance consists of targeting workpieces and production steps suitable for laser processing in terms of cost effectiveness and quality enhancement, the development of techniques and procedures for such processing and the establishment of processing parameters and other pertinent data. The work is related to laser surface transformation hardening of steels. The response of a number of frequently used steels to such laser processing has been determined over a wide range of

processing parameters. Models and calculator programs for the prediction of laser hardening have been developed and tested, and the necessary thermophysical constants of the various materials determined by statistical and empirical means. In addition to the transformation hardening survey, process development work relating to the laser hardfacing of aircraft carrier catapult rails has been performed, and preliminary techniques and processing data established for different combinations of hardfacing alloys/substrate materials. GRA

N86-28186# National Bureau of Standards, Gaithersburg, Md.
MATERIALS TECHNOLOGY FOR ELECTRICAL APPLIANCES: MAGNETIC AND ELECTRICAL PROPERTIES OF METALS AND ALLOYS
G. N. DUBININ and Y. S. AVRAAMOV 1985 277 p Transl. into ENGLISH of the mono. "Konstruktsionnye, Provodnikove i Magnitnye Materialy (Elektromaterialovedenie)" Moscow, USSR, Mashinostroenie, 1973 p 1-268 Sponsored by NSF
(PB86-184314; TT-79-52021) Avail: NTIS HC A13/MF A01 CSCL 11F

Described are the theoretical principles of the materials technology for electrical appliances used in aviation instrumentation. Major attention has been paid to the structure and properties of metals and alloys used in modern aviation instrumentation. The authors have elaborated the relationship between the structure and physiochemical properties of alloys. Various methods of developing special properties in alloys have been described. A considerable part of the book has been devoted to the study of special-purpose alloys such as soft and hard magnetic materials, ferrites, alloys with special thermal and electrical properties, and semiconductors. Students in aviation institutes will find the book very useful. Aviation, electrical and mechanical engineers engaged in the development of electrical appliances will also benefit from the book. GRA

N86-28193 National Physical Lab., Teddington (England). Div. of Materials Applications.
CHARACTERISATION AND INFLUENCE OF ORIENTATION AND INTERNAL STRESS IN ACRYLIC AIRCRAFT MATERIALS Final Report
B. E. READ, G. D. DEAN, and J. C. DUNCAN Dec. 1985 79 p
(Contract MOD-RAE(F)MT-69/2/10)
(NPL-DMA(A)113; ISSN-0143-7313; ESA-86-97132) Avail: Issuing Activity

A photoelastic method for characterizing the internal stresses in crosslinked PMMA acrylic aircraft materials and windows was developed. The time-dependence of optical birefringence during creep or relaxation tests at different temperatures suggests that three nonequilibrium internal stress components operate: stress characteristic of the molecular orientation produced by stretching at high temperature; a glasslike distortional stress; and a stress arising from molecular conformational changes generated by the beta relaxation process in PMMA. A light-scattering technique was used to characterize internal stresses from temperature-dependent birefringence measurements in biaxially oriented materials. Levels of molecular orientation in biaxially stretched sheets and windows correspond to an orientational stress of 2 + or - 0.2 MPa along each of the stretching directions. Internal stresses in the crosslinked acrylic materials can be assessed from surface acoustic wave velocity. ESA

N86-28236# University of Southern California, Los Angeles.
A NOVEL FEEDBACK CONCEPT FOR COMBUSTION INSTABILITY IN RAMJETS
P. R. CHOUDHURY, M. GERSTEIN, and R. MOJARADI *In* Johns Hopkins Univ. The 22nd JANNAF Combustion Meeting, Vol. 1 p 279-287 Oct. 1985
(Contract AF-AFOSR-0222-82)
Avail: CPIA, Laurel, Md. 20707 HC $70.00 CSCL 21B

Many dump combustors exhibit low frequency longitudinal combustion instability in the frequency range of 80 to 300 Hz. Although the exact causes of combustion instability are not known precisely, it is generally accepted that the interaction of the shock induced pressure pulsation and the coherent vortex shedding at the dump plane induces combustion instability. When the coherence of the shear layer at the dump plane is disrupted either by gasjets or by upstream protrusions the effect of combustion instability is found to be minimized. The control system suggested here is based upon the idea of disrupting the shear layer at the dump plane by means of pulsing gasjets. The control system senses the critical combination of frequency, amplitude and phase angle upstream of the combustor and actuates the gasjets at the dump plane at an appropriate combination of frequency, amplitude and phase angle to partially negate the effect of upstream pressure pulsation. Experiments in two laboratory scale two-dimensional (6.4 cm x 3.8 cm and 7.6 cm x 2.54 cm) dump combustors using premixed propane-air mixtures show the feasibility of reducing chamber pressure amplitude by such a technique. Author

N86-29028# Air Force Inst. of Tech., Wright-Patterson AFB, Ohio. Mechanical Behavior of Materials Lab.
CRACK GROWTH IN TITANIUM ALLOYS UNDER THE CONJOINT ACTION OF HIGH AND LOW CYCLE FATIGUE Final Report, 15 Jun. 1983 - 14 Jun. 1985
B. E. POWELL and I. HENDERSON Feb. 1986 77 p
(Contract F49620-83-C-0116)
(AD-A166429; AFWAL-TR-85-4093) Avail: NTIS HC A05/MF A01 CSCL 11F

Fatigue crack propagation rates have been measured for two titanium-based aeroengine disc alloys using compact tension test pieces. The loading block employed simulates two features of the engine flight pattern. A major stress cycle represents the start-stop operation which leads to low cycle fatigue. In-flight vibrations, which may give rise to high cycle fatigue, are represented by superimposed minor cycles of high frequency. With a lifting policy of retirement for cause the useful lives of blades and discs are limited by the onset of minor cycle crack growth. The threshold values associated with the minor cycles have been used to predict this event. Similarly the method of linear summation has been used to predict the subsequent fatigue crack growth rates. These predictions are successful for Ti-6A1-4V, whilst for Ti-5331S they are found to be either accurate or safe. Although Ti-5331S displays a marginally greater resistance to the onset of minor cycle crack growth, of greater significance is its reduced crack growth rates prior to this event. As a consequence components fabricated from Ti-5331S will exhibit longer fatigue crack propagation lives when subjected to the conjoint action of high and low cycle fatigue. GRA

N86-29037# Societe Nationale Industrielle Aerospatiale, Paris (France).
THE FUTURE OF SURFACE TREATMENTS IN AERONAUTICAL CONSTRUCTION [L'AVENIR DES TRAITEMENTS DE SURFACE EN CONSTRUCTION AERONAUTIQUE]
G. SERTOUR 29 Oct. 1985 8 p In FRENCH
(SNIAS-861-551-101; DCQ-1/85; ESA-86-97176) Avail: NTIS HC A02/MF A01

Surface treatments employed in the aeronautical industry and their evolution trends are presented. Aluminum or titanium alloy protection by electrolytic deposits, anodization, and vacuum or plasma deposits; the surface treatment of composite materials by paint or metallization; and the corrosion protection of refractory alloys by vapor phase diffusion of aluminum or chrome are considered. Fretting corrosion is shown to remain an unsolved problem related to several degradation and fatigue phenomena. ESA

N86-29039* National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

PROCESS FOR PREPARING ESSENTIALLY COLORLESS POLYIMIDE FILM CONTAINING PHENOXY-LINKED DIAMINES Patent

A. K. STCLAIR and T. L. STCLAIR 17 Jun. 1986 8 p Filed 23 Aug. 1984 Supersedes N85-20128 (23 - 11, p 1611) (NASA-CASE-LAR-13353-1; US-PATENT-4,595,548; US-PATENT-APPL-SN-643524; US-PATENT-CLASS-264-236; US-PATENT-CLASS-264-204; US-PATENT-CLASS-264-216; US-PATENT-CLASS-264-347; US-PATENT-CLASS-528-222; US-PATENT-CLASS-528-341; US-PATENT-CLASS-528-183)

Avail: US Patent and Trademark Office CSCL 11C

A polyimide film that is approximately 90% transparent at 500 nm, useful for thermal protective coatings and solar cells, and the processes for preparing the same by thermal and chemical conversion are disclosed. An essential feature for achieving maximum optical transparency films requires utilizing recrystallized and/or sublimated specific aromatic diamines and dianhydride monomers and introducing phenoxy or thiophenyl separator groups and isomeric m,m' or o,p'-oriented diamines into the polymer molecular structure. The incorporation of these groups in the polymer structure serves to separate the chromaphoric centers and reduce the formation of inter-chain and intra-chain charge transfer complexes which normally cause absorptions in the UV-visible range. The films may be obtained by hand, brushing, casting, or spraying a layer of polyamic acid solutions onto a surface and thermally converting the applied layer to the polyimide, or the polyamic acid solution can be chemically converted to the polyimide, subsequentially dissolved in an organic solvent, and applied as a polyimide film layer with the solvent therein thermally removed. Author

N86-29242# Boeing Vertol Co., Philadelphia, Pa.

A STUDY OF THE POTENTIAL BENEFITS ASSOCIATED WITH THE DEVELOPMENT OF A DEDICATED HELICOPTER TRANSMISSION LUBRICANT

R. J. DRAGO, P. J. MANGIONE (Naval Air Propulsion Test Center, Trenton, N.J.), and R. D. WENDRZYCKI *In* AGARD Aircraft and Bearing Tribological Systems 11 p Feb. 1986

Avail: NTIS HC A11/MF A01

A common oil is now used in both the engines and transmissions of virtually all U.S military helicopters. While this provides significant logistic advantages, these advantages are attained only by compromising the optimization of the oil for either system. The results of two studies undertaken to determine what benefits would accure through the development of a special oil tailored specifically to meet the unique requirements of high-speed, heavily loaded helicopter transmission systems are summarized. These studies, conducted independently by two major helicopter manufacturers under the direction of the Naval Air Propulsion Center, addressed specific problem areas as related to typical production aircraft in order to reach well-documented conclusions. In addition, the effect of the availability of such a special gearbox lubricant on the development of other advanced-technology components was evaluated and documented. Author

N86-29244# Messerschmitt-Boelkow-Blohm G.m.b.H., Munich (West Germany).

REQUIREMENTS ON LUBRICATION OIL FROM THE VIEW OF A HELICOPTER MANUFACTURER

J. HARTMANN and W. JONDA *In* AGARD Aircraft and Bearing Tribological Systems 6 p Feb. 1986

Avail NTIS HC A11/MF A01

Experience with known oil types, used in helicopters for transmissions, engines, hydraulics and brakes has shown that 3 main conditions if available, would improve drastically the performance of the aircraft. These 3 main conditions are: the same type of oil should be usable for all the above mentioned systems; the oils brands, produced according to a common specification, but by different manufacturers, should be mixable without restrictions; and some features of the oil, which are specially important for helicopter operations, should be improved. Author

N86-29245# Army Materials and Mechanics Research Center, Watertown, Mass. Physical Metallurgy Branch.

DIRECTION OF R AND D AND CURRENT STATUS OF UNDERSTANDING OF ADVANCED GEAR STEELS

P. J. FOPIANO, J. E. KRZANOWSKI, and G. M. CRAWFORD *In* AGARD Aircraft and Bearing Tribological Systems 15 p Feb. 1986

Avail NTIS HC A11/MF A01

High performance gears in the modern helicopter must operate at ever increasing torque and RPM. A major consequence of this increased torque and RPM is a significant increase in the surface temperature and increased scuffing of the gears. In response to this problem, Boeing-Vertol introduced a new class of steel (hot work tool steel) as a high performance aircraft gear steel and started a trend which all subsequent work has confirmed to be a correct decision. The three most prominent candidate critical high temperature aircraft gear steels including Vasco X-2M, CARTECH X-53 (PYROWEAR 53), and CBS600 are discussed. The heat treatment responses of these alloys will be compared. Three additional alloys (M50NiL, CBS1000M, and AMAX B) are discussed in less detail. Author

N86-29249# Air Force Aero Propulsion Lab., Wright-Patterson AFB, Ohio.

MILITARY AIRCRAFT PROPULSION LUBRICANTS: CURRENT AND FUTURE TRENDS

G. A. BEANE, IV, L. J. GSCHWENDER, C. E. SNYDER, JR., and J. T. SHIMSKI (Naval Air Propulsion Test Center, Trenton, N.J.) *In* AGARD Aircraft and Bearing Tribological Systems 16 p Feb. 1986

Avail: NTIS HC A11/MF A01

An assessment of the performance of MIL-L-7808J and MIL-L-23699C Military Specification lubricating oils in turbine engines and helicopter gear boxes is presented along with predicted performance of current and upgraded military specification oils in advanced and growth engine designs. Data is presented on advanced ester base engine lubricants, corrosion inhibited engine oils, and separate helicopter gear box oils evolving from current developmental research efforts. Future high temperature candidate fluids representing the ultimate stability for turbine engine oils are also discussed. Their use, in most cases, entails engine design considerations to accommodate their unique properties. The advantages and disadvantages of the various classes of synthetic lubricants for turbine engine applications are discussed, and deficiencies are identified where additional research programs are needed. Author

N86-29250# Imperial Coll. of Science and Technology, London (England).

FUTURE TRENDS IN HELICOPTER TRANSMISSION LUBRICANTS

H. A. SPIKES *In* AGARD Aircraft and Bearing Tribological Systems 10 p Feb. 1986

Avail: NTIS HC A11/MF A01

Some recent fundamental studies relating to the lubrication of helicopter transmissions are presented, as well as implications for future oil development. The resulting enhanced understanding of lubrication mechanisms has shown that real potential exists both for improved performance and for the ability to cater to higher temperatures, by means of the formulation and use of improved transmission oils. If such benefits are recognized and if the new knowledge is correctly applied, there is no reason why helicopter gearbox reliability should not be appreciably improved by the end of the decade. Author

N86-29251# Motoren- und Turbinen-Union Muenchen G.m.b.H. (West Germany).
AIRCRAFT ENGINE OILS AND THEIR BEHAVIOUR AT HIGH TEMPERATURES
K. MAIER *In* AGARD Aircraft and Bearing Tribological Systems 12 p Feb. 1986
Avail: NTIS HC A11/MF A01

Characteristics of aero-engine oils are changed considerably under high-temperature conditions (200 to 250 C). Consequences of this are the formation of aging products and deposits, deficiences in the tribological behavior and spontaneous ignition, in extreme cases. The problems arising from these are illustrated using several selected examples, and their effects on engine functioning are described. Author

N86-29253# Technische Univ., Munich (West Germany).
SCORING TESTS OF AIRCRAFT TRANSMISSION LUBRICANTS AT HIGH SPEEDS AND HIGH TEMPERATURES
H. WINTER and K. MICHAELIS *In* AGARD Aircraft and Bearing Tribological Systems 9 p Feb. 1986
Avail: NTIS HC A11/MF A01

Aircraft engines always contain gears that have to be lubricated under conditions of high speeds and extremely high temperatures. In this field of application scoring damage is likely to occur. In Europe and partly also in the USA the scoring load capacity of gear oils is expressed in terms of FZG Scoring Load Stage. The FZG Gear Test Rig is described. The normal test procedure A/8.3/90 as standardized in DIN 51 354 using A-type gears at a pitch line velocity of $v = 8.3$ m/s and a starting oil temperature of 90 C is presented. A modified procedure at double speed and increased oil temperature A/16.6/140 is discussed. Because of the high costs and problems with the availability of test gears a modified FZG Ryder Test was developed. The method is presented and comparative results of typical aircraft engine oils in the FZG, the FZG-Ryder and the original Ryder Gear Test are shown. From this experience it becomes obvious that alternative test methods for the evaluation of scoring load capacity of aircraft transmission lubricants can be available in the near future. Author

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ENGINEERING

Includes engineering (general); communications; electronics and electrical engineering; fluid mechanics and heat transfer; instrumentation and photography; lasers and masers; mechanical engineering; quality assurance and reliability; and structural mechanics.

A86-40109#
OPTIMAL DESIGN OF ANTISYMMETRIC LAMINATED COMPOSITE PLATES
N. G. R. IYENGAR (Arizona, University, Tucson) and S. P. JOSHI (Purdue University, West Lafayette, IN) (Structures, Structural Dynamics, and Materials Conference, 26th, Orlando, FL, April 15-17, 1985, Technical Papers. Part 1, p. 673-678) Journal of Aircraft (ISSN 0021-8669), vol. 23, May 1986, p. 359, 360. Previously cited in issue 13, p. 1896, Accession no. A85-30299. refs

A86-40215
INCOHERENT IMAGING OF RADAR TARGETS
A. VAN OMMEN and G. A. VAN DER SPEK (Centrale Organisatie voor Toegepast-Natuurwetenschappelijk Onderzoek, Physisch Laboratorium TNO, The Hague, Netherlands) Electronics Letters (ISSN 0013-5194), vol. 22, May 8, 1986, p. 548-550.

Theory suggests that, if a target can be modeled as a rigid constellation of point scatterers, the RCS pattern over a certain aspect change can be used to produce a one-dimensional image. The results for actual measured RCS patterns, however, are not promising. This is illustrated by processing on 4 s of echo data obtained from a Boeing 737 in straight flight, during which its aspect change is 2 deg. The conclusion might be that, for the application considered, aircraft cannot be modeled as a rigid constellation of point scatterers; this is partly due to the treatment of a three-dimensional target as a line target. B.J.

A86-40344* Vrije Universiteit, Brussels (Belgium).
THE COMBINED EFFECTS OF STRESS AND MOISTURE ON THE STRUCTURAL INTEGRITY OF COMPOSITES
C. HIEL, A. CARDON (Brussel, Vrije Universiteit, Brussels, Belgium), M. ADAMSON, and H. NELSON (NASA, Ames Research Center, Moffett Field, CA) IN: Developments in the science and technology of composite materials; Proceedings of the First European Conference on Composite Materials and Exhibition, Bordeaux, France, September 24-27, 1985 . Bordeaux, France, Association Europeenne des Materiaux Composites, 1985, p. 193-200. refs

A variational approach is used to model the moisture content and distribution profiles which cause swelling in polymers and composites which are used as aircraft structural components. The moisture intrusion stems from humidity, which makes the problem one of diffusion of mass from the environment into a semiinfinite plate with a given diffusion coefficient and thickness. Lagrangian, ordinary differential equations are defined for the mass diffusion, including driving force, mass potential and volume dissipation expressions. Account is taken of the effects of stress on diffusivity, including the dilatational stress caused by inhomogeneous swelling of the material. It is noted that material near the top and bottom of a part undergoes the most swelling, and the evolution of moisture diffusion in the materials is traced. Finally, experimental data are used to define differential equations for predicting the final moisture distribution within the material. M.S.K.

A86-40353
FAILURE ANALYSIS OF COMPOSITE ANGLE STRUCTURES
C.-T. SUN and S.-R. KELLY (Purdue University, West Lafayette, IN) IN: Developments in the science and technology of composite materials; Proceedings of the First European Conference on Composite Materials and Exhibition, Bordeaux, France, September 24-27, 1985 . Bordeaux, France, Association Europeenne des Materiaux Composites, 1985, p. 277-284. Research supported by the Boeing Aircraft Co.

Angle spars of laminated composites are analyzed using the finite element method. The resulting stresses are compared with the homogeneous and isotropic curved beam solution. Similarity of these solutions is noted. Failure criteria are evaluated based on existing experimental results. It is found that both interlaminar normal stress and bending stress in the curved section are responsible for causing delamination and thus total failure of the angle spar. Author

A86-40361
A MODEL FOR THE EQUIVALENT BENDING CHARACTERISTICS OF A COMPOSITE BEAM [CALCUL DES CARACTERISTIQUES EQUIVALENTES DE TORSION POUR UNE POUTRE COMPOSITE]
J.-J. BARRAU (Ecole Nationale Superieure de l'Aeronautique et de l'Espace, Toulouse, France) and D. GAY (Toulouse III, Universite, France) IN: Developments in the science and technology of composite materials; Proceedings of the First European Conference on Composite Materials and Exhibition, Bordeaux, France, September 24-27, 1985 . Bordeaux, France, Association Europeenne des Materiaux Composites, 1985, p. 373-378. In French.

A warping function is employed to obtain the torsional stiffness and the shear center of a composite beam in order to treat a composite helicopter blade with a model for a cylindrical beam applied to a homogeneous material. Equations are defined for the displacement field of the blade under rotation and for equilibrium conditions at the interface between the composite and another material and between the composite and the free surface. Bending forces are only exerted when the system is in equilibrium and always perpendicular to the blade. The bending stiffness is obtained

by integration of the moments exerted by the tangential stresses. A finite element method is then introduced for numerical solution of the beam under bending stress. Techniques for accelerating the convergence using either triagonal or one-dimensional elements in the computations are discussed. A sample problem is worked out for a carbon composite blade, showing that the model provides results within the bounds of experimental uncertainty. M.S.K.

A86-40403
SPECKLE EFFECTS ON COHERENT LASER RADAR DETECTION EFFICIENCY
J. C. LEADER (McDonnell Douglas Research Laboratories, Saint Louis, MO) Optical Engineering (ISSN 0091-3286), vol. 25, May 1986, p. 644-650. Research supported by the McDonnell Douglas Independent Research and Development Program. refs
(Contract N60921-79-C-0180)

Equations for laser radar heterodyne efficiency are derived by assuming that heterodyne detection is degraded by phase-front distortion produced by target speckle and atmospheric turbulence. These equations are numerically evaluated for representative target detection scenarios to illustrate the effects of laser speckle on coherent laser radar detection. Author

A86-40495
AUTOCLAVE, COMPRESSION MOULDING
K. BRUNSCH (Messerschmitt-Boelkow-Blohm GmbH, Munich, West Germany) IN: Carbon fibres and their composites . Berlin and New York, Springer-Verlag, 1985, p. 149-158.

Autoclave and compression molding are well-known technologies in use for the fabrication of fiber composite structures. This paper presents data gathered with autoclave curing of extremely thin, high modulus carbon fiber-composite (CFC) face skins for space structures, autoclave-curing of thickness tapered high tensile CFC skin of an aircraft taileron, press curing of thick high tensile strength CFC rotor hub components, and the use of an oven for vacuum bag curing. Author

A86-40509
ROBOTIC NONDESTRUCTIVE INSPECTION OF AEROSPACE STRUCTURES
G. L. WORKMAN and W. TEOH (Alabama, University, Huntsville) IN: Space tech; Proceedings of the Conference and Exposition, Anaheim, CA, September 23-25, 1985 . Dearborn, MI, Society of Manufacturing Engineers, 1985, p. 4-11 to 4-24.

Nondestructive inspection of critical components and systems used in aerospace structures requires that the inspection system provide a consistent scanning capability to determine structural integrity in a timely and cost-effective manner. The scanning system may be single-ended, as in pulse echo electronics or eddy currents, or double-ended as in through transmission ultrasonics or X-ray applications. Many of the scanning systems developed in the past for automated nondestructive inspection of large structures such as aircraft wings or fuselages usually are designed specifically for that application and can be very expensive. There is no built-in flexibility for scanning other types of structures; hence there is a need for general purpose scanning systems which use the industrial robot as a programmable scanning device. Author

A86-40527
A STUDY OF OPTIMIZING CUTTING TOOL PERFORMANCE IN HIGH TENSILE STRENGTH MATERIALS
J. GIEBLER (Prototyp-Werk GmbH, Zell am Harmersbach, West Germany) IN: Space tech; Proceedings of the Conference and Exposition, Anaheim, CA, September 23-25, 1985 . Dearborn, MI, Society of Manufacturing Engineers, 1985, p. 9-19 to 9-29.

This study shows the influences that different machining variables, in particular feed rates, have on cutting life and surface finish when milling or threading materials such as stainless steel, titanium and Inconel. Optimum machining values are easily determined by measuring the peak-to-valley heights of the surface texture finish. The study evaluates the performance of form threading Inconel 718 and the resulting advantages of such a procedure in practical application. Through the use of computer-aided design, special surface treatments and the application of the proper oils, the forming of Inconel 718 may achieve a high degree of success. Author

A86-40712#
OPTICAL DETERMINATION OF THE EFFECTS OF A MICROMINIATURE ACCELEROMETER ON RESONANCE OF A SMALL AIRFOIL
T. E. MCDEVITT and C. S. VIKRAM (Pennsylvania State University, State College) IN: Fluid measurements and instrumentation forum - 1986; Proceedings of the Fourth Fluid Mechanics, Plasma Dynamics, and Lasers Conference, Atlanta, GA, May 11-14, 1986 . New York, American Society of Mechanical Engineers, 1986, p. 73-75.

An experiment determining the influence of a microminiature accelerometer on the resonance of a small NACA 0015 blade is discussed. Time average holographic interferometry and an optical proximity sensor were used to record the resonance frequency and amplitude of the blade with and without the accelerometer while the blade was excited acoustically. Author

A86-40720#
SAMPLING OF SOLID PARTICLES IN CLOUDS
F. FEUILLEBOIS, A. LASEK, and M.-F. SCIBILIA (CNRS, Laboratoire d'Aerothermique, Meudon, France) IN: Gas-solid flows - 1986; Proceedings of the Fourth Fluid Mechanics, Plasma Dynamics, and Lasers Conference, Atlanta, GA, May 11-14, 1986 . New York, American Society of Mechanical Engineers, 1986, p. 139-144. refs

This paper is concerned with the sampling of small solid particles from clouds by an airborne apparatus to be mounted on an airplane for meteorological investigations. In the airborne experiment the particles entering the test tube should be as representative as possible of the upstream conditions ahead of the plane, in the real cloud. Due to the inertia of the particles, the proportion of the different sizes of particles entering the test tube depends on the location of the tube mouth. A method of calculating the real concentration in particles of different sizes is presented, using the results of measurements executed during the flight of an airplane in a cloud. Two geometries are considered: the nose of the airplane, represented schematically by a hemisphere, and a wing represented by a (2D) Joukowski profile which matches well a NACA 0015 profile on its leading edge. Author

A86-40733#
DILUTE GAS-PARTICLE FLOW IN A CENTRIFUGAL COMPRESSOR IMPELLER
H. LIU and C. MA (Xian Jiaotong University, Xian, People's Republic of China) IN: Turbomachinery performance deterioration; Proceedings of the Fourth Joint Fluid Mechanics, Plasma Dynamics, and Lasers Conference, Atlanta, GA, May 12-14, 1986 . New York, American Society of Mechanical Engineers, 1986, p. 67-73. refs

This paper presents computational results of particle trajectories of a dilute gas-particle flow in a centrifugal compressor impeller. The particle trajectory calculations are based on a three-dimensional gas flow field. Results show that pressure surfaces of blades and the joint regions of the hub and the pressure surfaces at the inlet and the outlet of the blade passage experience severe particle impacts. Considerations are also given to effects of material density and rebound characteristic on the particle motion. Author

A86-40734#
PARTICLE TRAJECTORIES IN FULL 3D FLOW FIELD OF TURBOMACHINERY
Z. G. LING (Shanghai University of Engineering Sciences, People's Republic of China) and S. L. HUANG (Chengdu University of Science and Technology, People's Republic of China) IN: Turbomachinery performance deterioration; Proceedings of the Fourth Joint Fluid Mechanics, Plasma Dynamics, and Lasers Conference, Atlanta, GA, May 12-14, 1986 . New York, American Society of Mechanical Engineers, 1986, p. 75-80. refs

In this paper, particle trajectories in turbine stages are predicted in connection with full 3D gas flow field solved by the time marching method. The secondary flow effect is also partially considered by assuming a total pressure distribution at the inlet of the moving blade row. The results show that passage vortex due to secondary flow will cause upward and downward divergence of particle trajectories at the rear part of near blade pressure surface, evidenced by the real appearance of eroded trace on turbine blade after a long period of operation. Author

A86-40775
DIGITAL SIMULATION OF REGULATED ELECTRICAL POWER SUPPLIES FOR MILITARY APPLICATIONS
V. V. VADHER and I. R. SMITH (Loughborough University of Technology, England) IN: Control 85; Proceedings of the International Conference, Cambridge, England, July 9-11, 1985. Volume 2 . London/New York, Institution of Electrical Engineers/IEE Inspec, 1985, p. 511-516.

The paper presents a generalized model for a regulated generator (for supplying power on board aircraft, military vehicles, or ships) which copes with the combined loading conditions likely to be encountered. The model is described in relation to an m-phase star-connected generator. The use of an additional but simple connection matrix is all that is necessary to enable the corresponding delta-connected machine to be considered. Simulation results are presented. B.J.

A86-41254
LARGE AND SMALL STRUCTURES IN THE COMPUTATION OF TRANSITION TO FULLY DEVELOPED TURBULENT FLOWS
P. PERRIER (Avions Marcel Dassault-Breguet Aviation, Saint-Cloud, France) IN: Macroscopic modelling of turbulent flows; Proceedings of the Workshop, Valbonne, France, December 10-14, 1984 . Berlin and New York, Springer-Verlag, 1985, p. 32-44. refs

How the large structures of turbulent flows have to be modellized, especially from the beginning of their onset, without any hypothesis based on fully developed turbulence, is discussed. A completely mathematical derived model is presented, given by homogenization theory. That model would be able to evaluate the size and behavior of large structures in the presence of statistical equilibrium of small structures. Author

A86-41261* Rutgers Univ., New Brunswick, N. J.
MODELLING OF THREE-DIMENSIONAL SHOCK WAVE TURBULENT BOUNDARY LAYER INTERACTIONS
D. D. KNIGHT (Rutgers University, New Brunswick, NJ) IN: Macroscopic modelling of turbulent flows; Proceedings of the Workshop, Valbonne, France, December 10-14, 1984 . Berlin and New York, Springer-Verlag, 1985, p. 177-201. NASA-supported research. refs
(Contract AF-AFOSR-82-0040)

The accuracy of numerical computations of the three-dimensional sharp fin flow field using the Reynolds-averaged Navier-Stokes equations is examined. Computed flows are compared with a set of benchmark experiments at Mach 3 for two different Reynolds numbers. A detailed comparison is performed between experimental data and separate computational results for the three-dimensional sharp fin for a 10 deg fin angle in order to examine the accuracy of two different turbulence models. The computed surface pressure for the fin at a 20 deg angle is compared with recent experimental data. The computed yaw angle profiles are shown to be sensitive to the turbulence model. In the immediate vicinity of the surface, the calculated results using the Baldwin-Lomax (1978) model are in better agreement with the data than the Jones-Launder (1972) model. Within the inner portion of the boundary layer, both models tend to underpredict the yaw angle. C.D.

A86-41574
PROBABILITY OF DETECTION OF FLAWS IN A GAS TURBINE ENGINE COMPONENT USING ELECTRIC CURRENT PERTURBATION
G. L. BURKHARDT and R. E. BEISSNER (Southwest Research Institute, San Antonio, TX) IN: Review of progress in quantitative nondestructive evaluation. Volume 4A - Proceedings of the Eleventh Annual Review, San Diego, CA, July 8-13, 1984 . New York, Plenum Press, 1985, p. 333-341. USAF-supported research.

The electric-current perturbation technique was used to estimate the probability of detection (POD) of surface flaws in blade slots of a F-100 turbofan first-stage Ti 6-2-4-6 fan disk with the objective of reliable flaw detection. At the retirement-for-cause target flaw size of 0.010-in-long and 0.005-in-deep, EDM slots were used to simulate fatigue cracks. POD as a function of flaw size was estimated from the POD data obtained from experimentally determined probability density functions for background and flaw signals. Depending on the scan track spacing, the POD was found to be close to 100 percent for flaw lengths of about 0.011 to 0.013 in. In parts with background noise lower than that in the F-100 first-stage fan disk blade slots, a higher POD for even smaller flaws can be achieved. I.S.

A86-41576
APPLICATION OF A COMPUTER MODEL TO ELECTRIC CURRENT PERTURBATION PROBE DESIGN
R. E. BEISSNER and G. L. BURKHARDT (Southwest Research Institute, San Antonio, TX) IN: Review of progress in quantitative nondestructive evaluation. Volume 4A - Proceedings of the Eleventh Annual Review, San Diego, CA, July 8-13, 1984 . New York, Plenum Press, 1985, p. 371-378.
(Contract W-7405-ENG-82)

The use of computer models of electromagnetic NDE probes to aid in probe design and applications is illustrated using examples. The miniaturization of the type of probe being considered which is of the electric current perturbation design, is addressed, considering the flaw responses of alternative configurations and their relevance to the inspection of a certain feature of an F100 engine part. Then, the use of the computer models to help determine the optimum frequency for subsurface flaw detection in the presence of near-surface anomalies that tend to mask the flaw signal is addressed, including the choice of operating frequency and phase shift to maximize the signal-to-noise ratio. C.D.

A86-41581
AUTOMATIC EDDY CURRENT INSPECTION OF ANTIROTATION WINDOWS IN F100 ENGINE COMPRESSOR AIR SEALS
W. HOPPE and D. STUBBS (Systems Research Laboratories, Inc., Dayton, OH) IN: Review of progress in quantitative nondestructive evaluation. Volume 4A - Proceedings of the Eleventh Annual Review, San Diego, CA, July 8-13, 1984 . New York, Plenum Press, 1985, p. 463-474.
(Contract F33615-81-C-5002)

A procedure for separating the notch signal detected by a probe from the geometry signal is proposed. A differential pencil probe is utilized to scan an aircraft engine air seal that contains six antirotation windows, three of which contain electrical discharge machine notches. The problems with separating the notch signal from the geometry signal by subtracting the geometry signal from the inspection signal or filtering data using analog digital filters are discussed. The difference between the mean frequencies of the vertical and horizontal components of the impedance plane versus time detected in the notch signal is examined. It is observed that the geometry signal is in both the time and frequency domains. The horizontal and vertical components are calculated and a correlation between the components is obtained. Examples are presented revealing the applicability of this procedure for detecting

notch signals based on differences in the vertical and horizontal components of the impedance plane. I.F.

A86-41582
AUTOMATIC EDDY CURRENT HOLE CENTERING FOR AIRCRAFT ENGINE COMPONENTS
D. STUBBS, W. HOPPE, and B. OLDING (Systems Research Laboratories, Inc., Dayton, OH) IN: Review of progress in quantitative nondestructive evaluation. Volume 4A - Proceedings of the Eleventh Annual Review, San Diego, CA, July 8-13, 1984 . New York, Plenum Press, 1985, p. 475-481.
(Contract F33615-81-C-5002)

An algorithm for centering a rotating eddy current hole probe over a hole is presented. Results show this algorithm to be fast, accurate, reliable, and flexible for a wide range of probe diameters, with attainable accuracies better than 0.0005 arcsec. Evidence is presented showing the applicability of this algorithm to cases where the probe is off center by more than the probe diameter. Data are also presented which show the ability of the algorithm to compensate for nearby geometries that adversely affect the centering procedure. C.D.

A86-41596
AN ANALYSIS OF ACOUSTIC EMISSION DETECTED DURING FATIGUE TESTING OF AN AIRCRAFT
C. M. SCALA, R. A. COYLE, and S. J. BOWLES (Department of Defence, Aeronautical Research Laboratories, Melbourne, Australia) IN: Review of progress in quantitative nondestructive evaluation. Volume 4B - Proceedings of the Eleventh Annual Review, San Diego, CA, July 8-13, 1984 . New York, Plenum Press, 1985, p. 709-718. refs

Preliminary results are presented from an evaluation of the effectiveness of in-flight acoustic emission (AE) monitoring of fatigue cracking in the wing spars of Mirage aircraft. Various types of AE sensors were examined prior to selection of thin-disk and conical sensors to aid in the pattern recognition signal processing. The pattern recognition codes provided the capability of discerning among saturation data, signal rise-time and duration data, time-domain shape factors, and spectral data, and allowed the performance of autocorrelations. Laboratory-scale pretests characterized inclusion fracture signals as opposed to those from gas flow, em interference, mechanical noise, etc. Sensors were then inserted into wing spar fastener holes of two aircraft wings that were monitored in-flight from 1981-82. Data from one wing proved insufficient for distinguishing between the waveforms emitted by inclusion fractures and from fretting sources. Additional trials were planned which may provide the necessary data for improving the applicability of the AE data. M.S.K.

A86-41605
A FIBER OPTIC DAMAGE MONITOR
C. K. JEN, P. CIELO (National Research Council of Canada, Industrial Materials Research Institute, Boucherville, Canada), G. W. FARNELL, and M. PARKER (McGill University, Montreal, Canada) IN: Review of progress in quantitative nondestructive evaluation. Volume 4B - Proceedings of the Eleventh Annual Review, San Diego, CA, July 8-13, 1984 . New York, Plenum Press, 1985, p. 831-838. NSERC-supported research.

A simplified fiber-optic damage monitoring system for on-line assessments of the condition of composite structural materials in F/A-18 fighters is described. Optical fibers are implanted into the composite mesh in a configuration with horizontal and vertical orientations. When light is pumped into the fibers, and failure of transmittance in either the x- or y-coordinates indicates the location of a defect at that coordinate, as revealed by the fiber damage. Attaching photodiodes to the optic fibers and connecting the entire system to a video camera and computer permits on-line monitoring of the mesh-holding panels. Sample results are provided from a system with multimode step index fibers, a VAX 11/780 computer and a video camera with a 488 x 380 cell photodiode array. Image subtraction is an effective means for fast determination of the identities of broken fibers by comparisons of images of arrays of original and damaged fibers. M.S.K.

A86-41631
APPLICATION OF MEDICAL COMPUTED TOMOGRAPHY (CT) SCANNERS TO ADVANCED AEROSPACE COMPOSITES
K. D. FRIDDELL, A. R. LOWREY, and B. M. LEMPRIERE (Boeing Aerospace Co., Seattle, WA) IN: Review of progress in quantitative nondestructive evaluation. Volume 4B - Proceedings of the Eleventh Annual Review, San Diego, CA, July 8-13, 1984 . New York, Plenum Press, 1985, p. 1239-1245; Discussion, p. 1246.

Computed tomography (CT), developed for medical scans of the human body, is based on the properties of carbon, which is fortuitous for adaptations to NDE of carbon composite materials (CCM). The defects which must be detected in CCM are wrinkling or damage to plies, drying, porosity and microcracks. In attempts to calibrate a CT device for NDE of CCM, specimens were prepared which were composed mainly of compacted powder with water, glycerine and plexiglass additives. Gray scales for density were obtained and compared with wafer-thin samples of the specimens. The technique proved useful not only for measuring density, but also for detecting microcracking. Furthermore, stress tests and subsequent scans of ring-shaped samples demonstrated that the strength of a piece as a whole was dependent on the weakest site, i.e., the lowest density region. M.S.K.

A86-41673* Georgia Inst. of Tech., Atlanta.
CONSTITUTIVE MODELING OF CYCLIC PLASTICITY AND CREEP, USING AN INTERNAL TIME CONCEPT
O. WATANABE and S. N. ATLURI (Georgia Institute of Technology, Atlanta) International Journal of Plasticity (ISSN 0749-6419), vol. 2, no. 2, 1986, p. 107-134. refs
(Contract NAG3-46)

Using the concept of an internal time as related to plastic strains, a differential stress-strain relation for elastoplasticity is rederived, such that (1) the concept of a yield-surface is retained; (2) the definitions of elastic and plastic processes are analogous to those in classical plasticity theory; and (3) its computational implementation, via a 'tangent-stiffness' finite element method and a 'generalized-midpoint-radial-return' stress-integration algorithm, is simple and efficient. Also, using the concept of an internal time, as related to both the inelastic strains as well as the Newtonian time, a constitutive model for creep-plasticity interaction, is discussed. The problem of modeling experimental data for plasticity and creep, by the present analytical relations, as accurately as desired, is discussed. Numerical examples which illustrate the validity of the present relations are presented for the cases of cyclic plasticity and creep. Author

A86-41699*# Virginia Polytechnic Inst. and State Univ., Blacksburg.
RESPONSE OF COMPOSITE MATERIAL SHALLOW ARCH TO CONCENTRATED LOAD
E. R. JOHNSON (Virginia Polytechnic Institute and State University, Blacksburg), M. W. HYER (Maryland, University, College Park), and D. M. CARPER (United Technologies Corp., Materials Engineering and Research Dept., Middletown, CT) (Structures, Structural Dynamics and Materials Conference, 25th, Palm Springs, CA, May 14-16, 1984, Technical Papers. Part 1, p. 310-321) Journal of Aircraft (ISSN 0021-8669), vol. 23, June 1986, p. 529-536. Previously cited in issue 13, p. 1911, Accession no. A84-31660. refs
(Contract NCC1-15)

A86-41714#
EIGENVALUE REANALYSIS OF LOCALLY MODIFIED STRUCTURES USING A GENERALIZED RAYLEIGH'S METHOD
B. P. WANG (Texas, University, Arlington) and W. D. PILKEY (Virginia, University, Charlottesville) AIAA Journal (ISSN 0001-1452), vol. 24, June 1986, p. 983-990. Army-supported research. refs
(AIAA PAPER 84-0972)

Approximate eigenvalue reanalysis methods for locally modified structures are developed based on the generalized Rayleigh's quotients. For simple modifications such as adding springs and masses or changing the truss member's cross-sectional area,

closed-form formulas are included. Several applications are presented. Author

A86-41715#
WEIGHT MINIMIZATION OF ORTHOTROPIC FLAT PANELS SUBJECTED TO A FLUTTER SPEED CONSTRAINT
L. LIBRESCU and L. BEINER (Tel Aviv University, Israel) (ICAS, Congress, 14th, Toulouse, France, September 9-14, 1984, Proceedings. Volume 2, p. 1188-1196) AIAA Journal (ISSN 0001-1452), vol. 24, June 1986, p. 991-997. Previously cited in issue 22, p. 3256, Accession no. A84-45060. refs

A86-41883
WEIBULL-DISTRIBUTED GROUND CLUTTER IN THE FREQUENCY DOMAIN
M. SEKINE, T. MUSHA (Tokyo Institute of Technology, Yokohama, Japan), Y. TOMITA, T. HAGISAWA, and E. KIUCHI (NEC Corp., Radio Application Div., Fuchu, Japan) Institute of Electronics and Communication Engineers of Japan, Transactions, Section E (English) (ISSN 0387-236X), vol. E68, June 1985, p. 365-370. refs

Ground clutter from cultivated land was measured using an L-band long range air-route surveillance radar at very low grazing angles, between 0.21 and 0.32 deg. It is shown that the Weibull-distributed ground clutter obeys a Weibull distribution in the frequency domain after processing by the discrete Fourier transform. Thus the new Weibull/CFAR should be considered to suppress such clutter in the frequency domain. Author

A86-42075
A LARGE DISPLACEMENT FORMULATION FOR ANISOTROPIC BEAM ANALYSIS
M. BORN and T. MERLINI (Milano, Politecnico, Milan, Italy) Meccanica (ISSN 0025-6455), vol. 21, March 1986, p. 30-37. refs

The displacement of a slender prismatic elastic beam, with constant properties along the generatrices and anisotropic and inhomogeneous properties in the cross section, in response to loading at the extreme cross-section surfaces is investigated analytically, expanding on the linear theory of Giavotto et al. (1983). The linear theory is shown to provide the correct elastic section properties and section warping characteristics; the nonlinear formulation gives a generalized geometric section stiffness which takes prestress into account. These results can then be used to construct the elastic and geometric stiffness matrices of a nonlinear beam element suitable for large-displacement analysis of structures such as helicopter rotor blades. T.K.

A86-42636*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
A DETAILED NUMERICAL MODEL OF A SUPERSONIC REACTING MIXING LAYER
J. P. DRUMMOND, R. C. ROGERS, and M. Y. HUSSAINI (NASA, Langley Research Center, Hampton, VA) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 22nd, Huntsville, AL, June 16-18, 1986. 18 p. refs
(AIAA PAPER 86-1427)

A current research effort is underway at the NASA Langley Research Center to achieve a detailed understanding of important phenomena present when a supersonic flow undergoes chemical reaction. A computer program has been developed to study the details of such flows. The program has been constructed to consider the multicomponent diffusion and convection of important species, the finite-rate reaction of these species, and the resulting interaction between the fluid mechanics and chemistry. Code results from the analysis of a spatially developing and reacting mixing layer are presented, and conclusions are drawn regarding the structure of the evolving layer and its associated flame. Author

A86-42658#
REDISTRIBUTION OF AN INLET TEMPERATURE DISTORTION IN AN AXIAL FLOW TURBINE STAGE
T. L. BUTLER, O. P. SHARMA, H. D. JOSLYN, and R. P. DRING (United Technologies Corp., East Hartford, CT) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 22nd, Huntsville, AL, June 16-18, 1986. 10 p. refs
(AIAA PAPER 86-1468)

The results of an experimental program aimed at determining the extent of the redistribution of an inlet temperature distortion in an axial flow turbine stage are presented. The program was conducted in a large-scale, low speed, single stage turbine where air, seeded with CO2 was introduced at one circumferential location upstream of the inlet guide vane. The migration of the seeded air through the turbine was determined by sensing CO2 concentration inside the stage. A temperature distortion was introduced by heating the seeded air. The CO2 concentration contours measured downstream of the vane showed little change with heating, indicating that the vane flowfield was relatively unaffected by the introduction of the temperature distortion. However, the CO2 contours observed on the rotor airfoil surfaces for the case with inlet heating indicated segregation of hot and cold gas, with the higher temperature gas migrating to the pressure side and the lower temperature gas migrating to the suction side. Significant increases in rotor secondary flow were also observed. Author

A86-42699#
SIMULATION OF ENGINE INSTALLATION FLOWFIELDS USING A THREE-DIMENSIONAL EULER/NAVIER-STOKES ALGORITHM
J. VADYAK and M. J. SMITH (Lockheed-Georgia Co., Marietta) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 22nd, Huntsville, AL, June 16-18, 1986. 14 p. Research sponsored by the Lockheed Independent Research and Development Program. refs
(AIAA PAPER 86-1537)

A computer analysis has been developed for calculating the steady (or unsteady) three-dimensional flowfield for engine installations. This algorithm, called ENS3D, can compute the engine installation flowfield for subsonic, transonic or supersonic free-stream speeds. The algorithm can solve either the Euler equations for inviscid flow, the thin-shear-layer Navier-Stokes equations for viscous flow, or the full Navier-Stokes equations for viscous flow. The flowfield solution is determined on a body-fitted numerically-generated computational grid. A fully-implicit alternating-direction-implicit method is employed for solution of the finite-difference equations. For viscous computations, a two-layer eddy-viscosity turbulence model is used to achieve mathematical closure. For the present application, the algorithm is applied to compute transport engine installation flowfields at subsonic and transonic free-stream speeds. Author

A86-42749#
INTERACTIONS BETWEEN ACOUSTICS AND VORTEX STRUCTURES IN A CENTRAL DUMP COMBUSTOR
K. KAILASANATH, J. GARDNER, J. BORIS, and E. ORAN (U.S. Navy, Naval Research Laboratory, Washington, DC) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 22nd, Huntsville, AL, June 16-18, 1986. 10 p. Navy-sponsored research. refs
(AIAA PAPER 86-1609)

Results are presented of numerical simulations performed to isolate and study the interaction between acoustic waves and large scale vortex structures in a central-dump ramjet combustor. A strong coupling between the acoustic modes of the chamber and large scale vortex structures is observed. The results in the early part of the calculations indicate unforced natural vortex growth near the entrance to the combustor (dump plane) at a frequency close to the acoustic frequency. With time, the acoustic modes shift the frequency of the most amplified mode near the dump plane into resonance with the acoustic mode. The location in space where the modes grow can also be shifted by acoustic forcing. An interesting feature observed in the simulations is a low frequency mode corresponding to the arrival of the merged

vortex structures at the choked exit. This mode causes major changes in the merging pattern of the vortices. Author

A86-42770*# Pratt and Whitney Aircraft, West Palm Beach, Fla.
FURTHER DEVELOPMENT OF THE DYNAMIC GAS TEMPERATURE MEASUREMENT SYSTEM
D. L. ELMORE, W. W. ROBINSON, and W. B. WATKINS (United Technologies Corp., Pratt and Whitney, West Palm Beach, FL) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 22nd, Huntsville, AL, June 16-18, 1986. 8 p.
(Contract NAS3-24228)
(AIAA PAPER 86-1648)

A compensated thermocouple measurement method was experimentally verified. Dynamic signal content from an atmospheric pressure laboratory burner was measured by the dynamic temperature sensor and a relatively delicate fine-wire resistance thermometer. Compensated data from the two dynamic temperature sensor thermoelements were compared with the compensated fine-wire data in the frequency domain. Absolute differences between spectral line amplitudes measured with different sensors are small relative to the mean temperature and verify the compenation method. Increases in precision of the measurement method require optimization of several factors, and directions for further work are identified. Author

A86-42781#
R&M 2000 - A LOOK TO THE FUTURE
F. S. GOODELL and M. P. SMITH (USAF, Office of the Special Assistant for Reliability and Maintainability, Washington, DC) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 22nd, Huntsville, AL, June 16-18, 1986. 7 p. refs
(AIAA PAPER 86-1668)

The U.S. Air Force's Reliability and Maintainability 2000 (R&M 2000) program has as its goals the enhancement of warfighting capability through increased combat support structure survivability measures that reduce mobility requirements for deploying units, decrease manpower requirements for each unit of output, and decrease costs. A key aspect of R&M 2000's implementation strategy is fault isolation down to shop replaceable units system levels in VHSIC technicology. R&M 2000 methods led to the cancellation of a radar warning receiver program that did not meet performance requirements, and resulted in the restructuring of the Low Altitude Navigation and Targeting IR System for Night. O.C.

A86-43084
DAMAGE TOLERANCE ASSESSMENT OF AIRCRAFT ATTACHMENT LUGS
T. R. BRUSSAT (Lockheed-California Co., Burbank, CA), K. KATHIRESAN (AT&T Bell Laboratories, Marietta, GA), and J. L. RUDD (USAF, Wright Aeronautical Laboratory, Wright-Patterson AFB, OH) Engineering Fracture Mechanics (ISSN 0013-7944), vol. 23, no. 6, 1986, p. 1067-1084. refs

A comprehensive development of damage tolerance design criteria nd analysis methods for aircraft attachment lugs is presented. A concise summary is presented of analysis methods and their correlation with test results from 236 fatigue crack growth and 16 residual strength tests of attachment lugs covering a wide variety of design variables. Logic is presented for the selection of an initial flaw size criterion, based upon a survey of cracking data, assessment of NDI capabilities and consideration of manufacturing quality for aircraft attachment lugs. Data are presented showing the damage tolerance of double element (redundant) lugs with a single initial flaw, but other data are discussed showing a high likelihood of multiple fatigue cracking in lugs. Logic is then presented for initial flaw size criteria for multi-load-path attachment lugs which give appropriate credit for redundancy without ignoring the possibility of multiple cracking. Author

A86-43090
THE OASIS STRUCTURAL OPTIMIZATION SYSTEM
B. J. D. ESPING (Kungl. Tekniska Hogskolan, Stockholm, Sweden) Computers and Structures (ISSN 0045-7949), vol. 23, no. 3, 1986, p. 365-377. refs

OASIS, a modular finite-element structural optimization system compatible with existing FE systems, is characterized and demonstrated. The formulation of the problem and the solution method are explained; design variables for rods, membranes, shells, and sandwiches are given; objective and constraint functions with quasi-numerical derivatives in the first-order approximations are derived; and the 11 modules making up OASIS are briefly described. Sample computations of a civil aircraft wing, a fighter wing, a fighter fin rudder, and a sandwich truck are presented in tables, graphs, and diagrams. T.K.

A86-43105
HOLOGRAPHIC MODE SHAPE INVESTIGATION OF AIRCRAFT ENGINE IMPELLERS
K. ANTROPIUS (Ceske Vysoke Uceni Technicke, Prague, Czechoslovakia) and A. PASLEROVA (Vyzkumny a Zkusebni Letecky Ustau, Prague, Czechoslovakia) IN: Optical methods in dynamics of fluids and solids; Proceedings of the International Symposium, Liblice, Czechoslovakia, September 17-21, 1984 . Berlin and New York, Springer-Verlag, 1985, p. 35-41. refs

The resonant mode shapes of several radial-bladed stationary impellers and of two radial blades removed from the impeller body were investigated by CW-laser holographic interferometry. The greatest attention was paid to the frequency range from 10 to 15 kHz. A retroreflective white paint was used for coating the impeller surface, which helped to enhance the fringes in real-time/time-average visualization, and to shorten the exposure times in hologram recording. Impeller excitation was performed by a set of 10 piezoelectric transducers. In cases with higher-amplitude vibrations a method of additional static exposure was applied. Author

A86-43109
EXPERIENCE WITH LABORATORY LDA BY MEASURING FLOW FIELDS IN ROTATING TURBOMACHINERY
J. GARDAVSKY, J. PLASEK (Karlova University, Prague, Czechoslovakia), V. DANEK, and J. MASA (CKD-Zavod Kompresory, Prague, Czechoslovakia) IN: Optical methods in dynamics of fluids and solids; Proceedings of the International Symposium, Liblice, Czechoslovakia, September 17-21, 1984 . Berlin and New York, Springer-Verlag, 1985, p. 65-74. refs

A laboratory LDA system is operated in the one-color dual-beam mode with confocal annular detection and polarizational separation of the backscattered Doppler signal, allowing for measurements of axial or tangential velocity components up to 600 m/s in absolute coordinates. Doppler signals between the blade passages are gated and evaluated by a counter. The operation of the system is illustrated by measurements of the axial-flow-field velocity component at the impeller of a research turbocharger. Author

A86-43328#
PROSPECTS FOR INTELLIGENT AEROSPACE STRUCTURES
W. J. ROWE (Lockheed-Georgia Co., Marietta) AIAA and SOLE, Aerospace Maintenance Conference, 2nd, San Antonio, TX, May 21-23, 1986. 10 p. refs
(AIAA PAPER 86-1139)

An evaluation is made of NDE sensor and instrumentation concepts that have demonstrated promise for the future monitoring of critical structures in flight, in light of past and current efforts to implement such systems and with a view to their operational and economic advantages. Attention is given to the NDE challenges posed by advanced composite laminates, which are affected by both manufacturing and service-incurred defects. Electrical resistance strain gages in various configurations, and optical fiber-based sensors, are considered as suitable bases for composite materials' NDE systems. O.C.

A86-43370
SOLUTION OF PROBLEMS OF CONJUGATE HEAT TRANSFER DURING FLOW PAST BODIES OF DIFFERENT SHAPE [RESHENIE ZADACH SOPRIAZHENNOGO TEPLOOBMENA PRI OBTEKANII TEL RAZLICHNOI FORMY]
V. I. ZINCHENKO and E. N. PUTIATINA PMTF - Zhurnal Prikladnoi Mekhaniki i Tekhnicheskoi Fiziki (ISSN 0044-4626), Mar.-Apr. 1986, p. 85-93. In Russian. refs

An analysis is made of unsteady heat transfer during the supersonic flow of an ideal gas past axisymmetric bodies of resolution of different shape for Reynolds numbers corresponding to different flow regimes in the boundary layer. Numerical and analytical solutions for heat flux from a nonisothermal surface are compared for laminar flow regimes. It is shown that, in the laminar case, the heat flux to the body has a structure connected with the preliminary development history of the thermal and dynamic boundary layer, and with the value of the local derivative of surface temperature. For certain surface shapes, the use of accepted formulas for the heat transfer coefficient leads to significant errors in the separable formulation of the problem of determining the temperature field in the body. B.J.

A86-43379
CALCULATION OF THE BALANCING EFFICIENCY OF FLEXIBLE ROTORS OF COMPRESSOR UNITS ON LOW-CYCLE BALANCING MACHINES [RASCHET EFFEKTIVNOSTI URAVNOVESHIVANIIA GIBKIKH ROTOROV KOMPRESSORNYKH AGREGATOV NA NIZKOCHASTOTNYKH BALANSIROVOCHNYKH STANKAKH]
A. I. GLEIZER and V. A. BULYCHEV Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 1, 1986, p. 15-19. In Russian.

A method for calculating the efficiency of the low-cycle balancing of flexible rotors on acceleration-type balancing machines is proposed. The method includes a probabilistic estimation of the residual unbalance and a calculation of the limiting level of support vibrations or rotor deflections. The data obtained are compared with norms of residual vibrations permitted under low-cycle balancing. B.J.

A86-43410
THERMAL STABILITY OF GAS TURBINE BLADES WITH PROTECTIVE COATINGS [TERMOSTOIKOST' LOPATOK GAZOVYKH TURBIN S ZASHCHITNYMI POKRYTIIAMI]
A. P. VOLOSHCHENKO, ED., G. N. TRETIACHENKO, ED., L. B. GETSOV, ED., B. M. ZINCHENKO, ED., I. S. MALASHENKO, ED. (Leningradskoe Ob'edinenie Proletarskii Zavod, Leningrad, USSR; AN USSR, Institut Elektrosvarki and Institut Problem Prochnosti, Kiev, Ukrainian SSR) et al. Problemy Prochnosti (ISSN 0556-171X), May 1986, p. 45-50. In Russian.

The thermal stability of turbine blade models with fused slurry and electron-beam coatings has been investigated in gas flow under conditions of thermal cycling, static loading, and sea water exposure. It is shown that blades of various high-temperature alloys (e.g., EP22VD, ZhS6U, EP539VD, and EP539LM) can be effectively protected against sulfide corrosion by using electron-beam coatings of the system Co-Cr-Al-Y. In order to achieve high thermal fatigue strength, tight control of the heating during coating deposition and heat treatment of the blades are essential. V.L.

A86-43411
A METHOD FOR THE ANALYTICAL DETERMINATION OF ACCELERATED TEST SCHEDULES FOR COMPRESSOR BLADES WORKING IN A CORROSIVE MEDIUM [METOD RASCHETNOGO OPREDELENIIA REZHIMOV USKORENNYKH ISPYTANII LOPATOK KOMPRESSOROV, RABOTAIUSHCHIKH V KORROZIONNOI SREDE]
L. B. GETSOV, A. V. PROKPENKO, and V. K. DONDOSHANSKII (AN USSR, Institut Problem Prochnosti, Kiev, Ukrainian SSR) Problemy Prochnosti (ISSN 0556-171X), May 1986, p. 55-60. In Russian. refs

A method is proposed for the analytical determination of accelerated test schedules for gas turbine engines whose effect in terms of the fatigue, corrosion, and erosion of compressor blades is equivalent to that of the entire service life. The method uses an idealized loading scheme and requires the knowledge of experimentally determined fracture toughness characteristics of the blade material. V.L.

A86-43430* Murray State Univ., Ky.
X-RAY FLUORESCENCE ANALYSIS OF WEAR METALS IN USED LUBRICATING OILS
W. E. MADDOX (Murray State University, KY) and W. C. KELLIHER (NASA, Langley Research Center, Hampton, VA) IN: Advances in X-ray analysis. Volume 29. New York, Plenum Publishing Corp., 1986, p. 497-502. refs
(Contract NCCC1-92)

Used oils from several aircraft at NASA's Langley Research Center were analyzed over a three year period using X-ray fluorescence (XRF) and atomic emission spectrometry. The results of both analyses are presented and comparisons are made. Fe and Cu data for oil from four internal combustion engines are provided and XRF and atomic emission spectrometry measurements were found to be in perfect agreement. However, distributions were found in the case of oil from a jet aircraft engine whereby the latter method gave values for total iron concentration in the oil and did not distinguish between suspended particles and oil additives. XRF does not have these particle-size limitations; moreover, it is a faster process. It is concluded that XRF is the preferred method in the construction of a man-portable oil wear analysis instrument. K.K.

N86-28237# San Diego State Univ., Calif. Dept. of Aerospace Engineering.
THE FLOWFIELD OF A SIDE-DUMP COMBUSTOR
N. NOSSEIR and S. BEHAR *In* Johns Hopkins Univ. The 22nd JANNAF Combustion Meeting, Vol. 1 p 289-294 Oct. 1985
(Contract N0014-84-K-0373)
Avail: CPIA, Laurel, Md. 20707 HC $70.00 CSCL 21B

Flow visualization is used to study the characteristics of the flowfield of a side-dump combustor. A two-dimensional combustor simulator, with water as the working fluid, is used in this experiment. In this configuration, two jets are introduced into the combustor through rectangular ports in the combustor's sides. The two jets impinge on each other at the plane of symmetry of the combustor. Counter-rotating vortex-pairs are generated near this plane. The axes of the vortices are parallel to the plane of symmetry of the combustor. The strength of the vortices changes periodically as they stretch along the downstream direction. The effects of changing the combustor dimensions on the generation of these vortices are investigated. Author

N86-28266# Air Force Systems Command, Wright-Patterson AFB, Ohio. Foreign Technology Div.
APPARATUS FOR THE PREPARATION OF AIR
N. S. NIKOLAYEV, Y. M. ITSKOVICH, A. V. SHCHERBAKOV, T. V. STOYANOVA, and V. V. GOLOVIN 12 Mar. 1986 10 p Transl. into ENGLISH of Russian Patent 302 279, 28 Apr. 1971 p 1-3
(AD-A165603; FTD-ID(RS)T-0134-86) Avail: NTIS HC A02/MF A01 CSCL 13G

The invention deals with equipment for ensuring the maximal reliable operation of devices that pneumatically control air conditioning systems. It can be used, in particular, in an apparatus for preparing air for devices of pneumatic control, for example, air conditioning on aircraft. GRA

N86-28309# Rijksluchtvaartdienst, The Hague (Netherlands).
FUTURE AERONAUTICAL COMMUNICATION SYSTEM (FACS): REPORT
H. J. HOF Jun. 1985 102 p In DUTCH
(ESA-86-96959) Avail: NTIS HC A06/MF A01

The feasibility of a FACS design, particularly with regard to application possibilities of satellites, was investigated. It was assumed that communication between airborne stations and air traffic control centers is exclusively possible via satellites using mainly voice communication (possibly completed by data

communication). It is concluded that integration possibilities of satellites are mainly limited by the airborne antenna chosen. As a solution, phase steered microstrip antenna arrays are presented. However, the use of these antennas is limited to large (long-distance) aircraft. For operational feasibility, it is concluded that communication should take place in the high frequency band. ESA

N86-28337# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France). Avionics Panel.
THE IMPACT OF VERY HIGH PERFORMANCE INTEGRATED CIRCUITS ON RADAR, GUIDANCE AND AVIONICS SYSTEMS
Loughton, England Aug. 1985 396 p In ENGLISH and FRENCH Symposium held in Lisbon, Portugal, 20-25 May 1985 (AGARD-CP-380; ISBN-92-835-0379-1) Avail: NTIS HC A17/MF A01

Advances with silicon integrated circuit technology have demonstrated the feasibility of very large scale integration with gate densities of 10 to the 5th power/sq cm and with functional throughput rates in excess of 10 to the 12th power gate Hz/sq cm. These advances offer the prospect of compact, low power consumption, high throughput processors in a wide variety of roles throughout military electronic systems. This symposium aimed to involve integrated circuit experts who reviewed ththeir current and projected capabilities, circuit and subsystems designers who are exploiting the technology in implementing sophisted processing and data manipulation techniques and who reported on their progress, and system designers who described applications addressed by the advancing technology.

N86-28341# TRW Electronics and Defense Sector, Redondo Beach, Calif. Microelectronics Center.
THE FUTURE OF BIPOLAR TECHNOLOGY FOR AVIONICS
B. DUNBRIDGE *In* AGARD The Impact of Very High Performance Integrated Circuits on Radar, Guidance and Avionics Systems 10 p Aug. 1985
Avail: NTIS HC A17/MF A01

In the past 25 years, silicon integrated circuit (IC) device technology has been heavily utilized in military and avionics systems due to primary advantages in availability, versatility, environmental ruggedness/reliability, and speed/frequency performance. Silicon n-channel metal oxide semiconductor (NMOS) technology has also rapidly developed and has been dominant for commercial applications due to its previous advantages of cost and density in modest environments, especially for standard memory and microprocessor functions. Complementary metal oxide semiconductor (CMOS) LSI/VLSI has more recently rapidly emerged as the dominant MOS device technology of the the future. The long held speed performance advantage of silicon bipolar ICS is also being challenged by the superior switching speed of GaAs field-effect transistor (FET) ICs. The question arises as to the future competitiveness and role of silicon bipolar. The question is further examined in this paper, especially for future avionics systems applications having heavy realtime digital signal processing requirements. B.W.

N86-28369# Thomson-CSF, Montrouge (France). Div. Equipements Avioniques.
THE APPLICATION OF HIGH-PERFORMANCE INTEGRATED CIRCUITS FOR AIRPORT FIRE CONTROL RADARS [INTERET DES CIRCUITS INTEGRES DE HAUTES PERFORMANCES POUR LES RADARS AEROPORTES DE CONDUITS DE TIR]
J. C. MARCHAIS *In* AGARD The Impact of Very High Performance Integrated Circuits on Radar, Guidance and Avionics Systems 4 p Aug. 1985 In FRENCH; ENGLISH summary
Avail: NTIS HC A17/MF A01

The number of functional modes needed for airport fire control radars, together with the need for high-performance characteristics, indicates that high-performance integrated circuits will have significant applications in such radar. It is shown that multi-function and multi-mode radars which combine air-to-air combat, air-to-ground and air-to-sea modes will comprise the basis for the next generation of fire control radars. Other applications for such radars are shown to include anti-collision, air navigation and air-to-air pursuit modes. Author

N86-28371# Aeritalia S.p.A., Caselle Torinese (Italy). Gruppo Sistemi Avionici ed Equipaggiamenti.
POSSIBLE IMPACTS OF VHSIC ON MIL-STD-1553B DATA TRANSMISSION MANAGEMENT
L. BERARDI and M. MERLANO *In* AGARD The Impact of Very High Performance Integrated Circuits on Radar, Guidance and Avionics Systems 12 p Aug. 1985
Avail: NTIS HC A17/MF A01

High performance integrated circuit technologies allow for dramatic improvement in speed and reduction in size of the integrated circuits. This fact results in the possibility to pack in a denser way the computing and decision making functions of the avionics systems. Nevertheless it is still necessary to connect together the various sytem components, spread through the airframe, by means of an interfunction data transmission system. For these reasons the application of the new technologies to a MIL-STD-1553B data transmission system is considered. In particular the data management task allocated to the Bus Controller is described in four increasing levels of complexity, ranging from the minimum requirement to an 'expert' function including an high degree of configurability. The performance obtainable by implementing the functions in the current or new technologies, and with two different architectural solutions, are measured or estimated. The comparison among the obtained results shows that the new technologies not only improve the performances of the data transmission system, but also allow to include an higher degree of intelligence in the function, extending in this way the application of MIL-STD-1553B to future advanced avionic systems. Author

N86-28372# Royal Aircraft Establishment, Farnborough (England). Flight Systems Dept.
THE IMPACT OF VHPIC ON AVIONIC SYSTEM ARCHITECTURE, PACKAGING AND MAINTAINABILITY
L. T. J. SALMON and D. E. OLDFIELD *In* AGARD The Impact of Very High Performance Integrated Circuits on Radar, Guidance and Avionics Systems 5 p Aug. 1985
Avail: NTIS HC A17/MF A01

The advent of high performance integrated circuit technology will have a far reaching effect on avionic systems. Currently, the impact is being mainly felt at a high bandwidth, signal processing level where the benefits are self-evident, however, unless the effect of the technology is considered across the whole of the avionic system then there is little doubt that much of the improved mission effectiveness promised by the new, high bandwidth systems will not accrue. A wider, system level approach is therefore needed which not only encompasses the technical aspects of individual sensors but also considers the remainder of the airborne data processing system and more traditional topics such as maintainability, packaging and architecture. This paper highlights some of the areas in which very high performance integrated circuits (VHPIC) could have a major impact on avionics systems and indicates some of the factors that will need to be considered during the design of future systems. Author

N86-28373# Westinghouse Electric Corp., Baltimore, Md. Advanced Technology Div.
THE IMPACT OF VERY HIGH PERFORMANCE INTEGRATED CIRCUITS ON AVIONICS SYSTEM READINESS
G. STRULL *In* AGARD The Impact of Very High Performance Integrated Circuits on Radar, Guidance and Avionics Systems 2 p Aug. 1985
Avail: NTIS HC A17/MF A01

Very high performance integrated circuits (VHPIC) represent more than an integrated circuit technology advance- VHPIC really represents a new systems/technology culture. With a philosophy of top-down design and bottom-up build, a vehicle is provided to avoid rapid obsolescence so prevalent in the fast moving integrated circuit industry. However, to successfully and effectively design advanced systems in this manner, a design methodology is required

that adequately addresses the challenge. Since everything from chip definition through application analysis is interactive with everything else, the challenge is to adequately keep track of all the perimeters and their relationship. The methodology by which design and analysis are accomplished is discussed. The starting point is the systems architecture and its application software. From the architecture and application software the partitioning of the system into appropriate modules can be derived. From this an idea of the integrated circuits needed can be determined. The elements of system readiness are described. They are design, implementation, insertion, maintenance, and (Preplanned Product Improvement). Author

N86-28374# British Aerospace Aircraft Group, Woodford (England). Aircraft Group.
THE IMPACT OF ARTIFICIAL INTELLIGENCE ON AIRBORNE MARITIME RECONNAISSANCE
J. SHEPARD and R. J. SCOTT-WILSON *In* AGARD The Impact of Very High Performance Integrated Circuits on Radar, Guidance and Avionics Systems 14 p Aug. 1985
Avail: NTIS HC A17/MF A01

Some of the problems arising out of the introduction of VHPIC to the sensor and data processing systems of Maritime Reconnaissance aircraft are susceptible to solution by conventional computing techniques within mission time constraints. Some may be more susceptible to the use of artificial intelligence techniques. This paper identifies those aspects of artificial intelligence relevant to the Airborne Maritime Reconnaissance task and the areas of the current task where artificial intelligence can be usefully applied. It reviews the current state of the art in the relevant aspects of artificial intelligence and indicates how they might be employed in the near, medium and long term. It indicates some future applications and concludes that, artificial intelligence will play an important role in the future Maritime Reconnaissance aircraft. Author

N86-28375*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
FEASIBILITY STUDY OF OPTICAL BOUNDARY LAYER TRANSITION DETECTION METHOD Final Report, 22 Feb. 1983 - 15 Nov. 1985
M. AZZAZY, D. MODARRESS, and J. D. TROLINGER Jun. 1986 179 p
(Contract NAS1-17293)
(NASA-CR-178109; NAS 1.26:178109; SLD-85-2285-47F) Avail: NTIS HC A09/MF A01 CSCL 20D

A high sensitivity differential interferometer was developed to locate the region where the boundary layer flow undergoes transition from laminar to turbulent. Two laboratory experimental configurations were used to evaluate the performance of the interferometer: open shear layer, and low speed wind tunnel turbulent spot configuration. In each experiment, small temperature fluctuations were introduced as the signal source. Simultaneous cold wire measurements were compared with the interferometer data. The comparison shows that the interferometer is sensitive to very weak phase variations in the order of 0.001 the laser wavelength. An attempt to detect boundary layer transition over a flat plate at NASA-Langley Unitary Supersonic Wind Tunnel using the interferometer system was performed. The phase variations during boundary layer transition in the supersonic wind tunnel were beyond the minimum signal-to-noise level of the instrument. Author

N86-28377*# Flow Research, Inc., Kent, Wash.
FEASIBILITY OF GENERATING AN ARTIFICIAL BURST IN A TURBULENT BOUNDARY LAYER
M. GAD-EL-HAK Washington NASA Aug. 1986 53 p
(Contract NAS1-17951)
(NASA-CR-4003; NAS 1.26:4003; REPT-332) Avail: NTIS HC A04/MF A01 CSCL 20D

Artificial bursts were generated in laminar and turbulent boundary layers. The burst-like events were produced by withdrawing near-wall fluid from two minute holes separated in the spanwise direction or by pitching a miniature delta wing that was flush-mounted to the wall. Either of these actions generated streamwise vorticity and a low-speed streak that resembled a naturally occurring one. The resulting sequence of events occurred at a given location and at controlled times, allowing detailed examination and comparison with natural, random bursts by means of flow visualization and fast-response probe measurement techniques. Author

N86-28385*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
FEASIBILITY OF A NUCLEAR GAUGE FOR FUEL QUANTITY MEASUREMENT ABOARD AIRCRAFT
J. J. SIGNH, G. H. MALL (Computer Sciences Corp., Hampton, Va.), D. R. SPRINKLE, and H. CHEGINI (Old Dominion Univ., Norfolk, Va.) Aug. 1986 25 p
(NASA-TM-87706; L-16132; NAS 1.15:87706) Avail: NTIS HC A02/MF A01 CSCL 14B

Capacitance fuel gauges have served as the basis for fuel quantity indicating systems in aircraft for several decades. However, there have been persistent reports by the airlines that these gauges often give faulty indications due to microbial growth and other contaminants in the fuel tanks. This report describes the results of a feasibility study of using gamma ray attenuation as the basis for measuring fuel quantity in the tanks. Studies with a weak Am-241 59.5-keV radiation source indicate that it is possible to continuously monitor the fuel quantity in the tanks to an accuracy of better than 1 percent. These measurements also indicate that there are easily measurable differences in the physical properties and resultant attenuation characteristics of JP-4, JP-5, and Jet A fuels. The experimental results, along with a suggested source-detector geometrical configuration are described. Author

N86-28389*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
IMPROVEMENT IN THE QUALITY OF FLOW VISUALIZATION IN THE LANGLEY 0.3-METER TRANSONIC CRYOGENIC TUNNEL
W. L. SNOW, A. W. BURNER, and W. K. GOAD 1986 24 p
(NASA-TM-87730; L-16108; NAS 1.15:87730) Avail: NTIS HC A02/MF A01 CSCL 14B

Optical diagnostic techniques have not been as successful in the 0.3-Meter Transonic Cryogenic Tunnel as in conventional wind tunnels. This paper describes a simple shadowgraph experiment which allowed evacuation of the optical paths outside the test section. The results show that refractive index variations induced by temperature gradients outside the test section account for most of the image degradation. Earlier reports had erroneously attributed this degradation to inhomogeneities in the test section. Evacuation of the paths leading to and from the test section significantly improves the quality of flow visualization. Author

N86-28463*# Aerostructures, Inc., Arlington, Va.
NASTRAN SUPPLEMENTAL DOCUMENTATION FOR MODAL FORCED VIBRATION ANALYSIS OF AERODYNAMICALLY EXCITED TURBOSYSTEMS
V. ELCHURI and P. R. PAMIDI (RPK Corp., Columbia, Md.) Jul. 1985 133 p
(Contract NAS3-24387)
(NASA-CR-174967; NAS 1.26:174967) Avail: NTIS HC A07/MF A01 CSCL 20K

This report is a supplemental NASTRAN document for a new capability to determine the vibratory response of turbosystems subjected to aerodynamic excitation. Supplements to NASTRAN Theoretical, User's, Programmer's, and Demonstration Manuals are included. Turbosystems such as advanced turbopropellers with highly swept blades, and axial-flow compressors and turbines can be analyzed using this capability, which has been developed and implemented in the April 1984 release of the general purpose finite element program NASTRAN. The dynamic response problem is addressed in terms of the normal modal coordinates of these tuned rotating cyclic structures. Both rigid and flexible hubs/disks are considered. Coriolis and centripetal accelerations, as well as

differential stiffness effects are included. Generally non-uniform steady inflow fields and uniform flow fields arbitrarily inclined at small angles with respect to the axis of rotation of the turbosystem are considered as the sources of aerodynamic excitation. The spatial non-uniformities are considered to be small deviations from a principally uniform inflow. Subsonic and supersonic relative inflows are addressed, with provision for linearly interpolating transonic airloads. Author

N86-28481# Societe Nationale Industrielle Aerospatiale, Toulouse (France). Div. Avions.
STRESS INTENSITY FACTOR IN AN INTEGRAL OR BONDED STIFFENED PANEL USING AN ANALYTICAL METHOD
J. M. THOMAS and B. LACHAUD 1986 20 p In FRENCH; ENGLISH summary Presented at Colloq. sur les Tendances en Calcul de Struct., Bastia, France, 6-8 Nov. 1985 Submitted for publication
(SNIAS-861-111-104; ESA-86-97141) Avail: NTIS HC A02/MF A01

A mathematical model of a stiffened panel is described. The element is decomposed in a set of subelements for which analytical solutions exist. The results are then superposed respecting the compatibility constraints. The method leads to an economical computation technique to evaluate, for instance, damage tolerance. It is also shown that it could be used for fundamental parametric studies associated with the design of an aircraft. ESA

N86-29082# Joint Publications Research Service, Arlington, Va.
PROPERTIES, APPLICATIONS, FUTURE OF EUROPEAN GYRO SENSORS
W. HANSLI *In its* Europe Report: Science and Technology (JPRS-EST-86-008) p 29-32 18 Jun. 1986 Transl. into ENGLISH from Wehrtechnik (Bonn, West Germany), Apr. 1986 p 62, 65-66 Avail: NTIS HC A06/MF A01

The mechanical gyroscope was used since the time of World War I as a sensor for measuring angular velocities for the purpose of navigation and flight control. The characteristic configuration was the fixed-in-space mount (cardan mount). With the appearance of the microprocessor, it is now possible to mount gyro devices fixed to the airframe (strapdown mount). Various gyro types are discussed as well as their specific suitability and areas of applications. Future prospects are also examined. B.G.

N86-29119# Army Aviation Systems Command, St. Louis, Mo.
VHF-FM COMMUNICATIONS ANTENNAS FOR PROJECT SINCGARS (UH-1 TAIL WHIP ANTENNA EVALUATION)
J. CARALYUS, J. MILLER, and F. CANSLER Feb. 1986 129 p
(AD-A165897; AVSCOM-TR-85-E-2) Avail: NTIS HC A07/MF A01 CSCL 17B

A full-scale study was conducted by the Naval Air Development Center, Warminster, Penn. (NADC), for the C3 Division of the U.S. Army Avionics Research and Development Activity (AVRADA), Fort Monmouth, N.J., to test and evaluate production prototype antenna systems that essentially met the requirement for SINCGARS operation when installed on an Army UH-1 helicopter. The results of these tests determined a suitable tail whip antenna to be used on the UH-1 to satisfy the SINCGARS requirement between 30 and 88 MHz. This technical report describes the results of tests conducted on antennas manufactured by three major Airborne Antenna manufacturers, each of whom attempted to provide an antenna system that would directly replace the standard Army CU-942B antenna, and satisfy the more stringent requirements of project SINCGARS. The information in this report provides, in part, the technical data for the production data package of an adequate VHF-FM Communications antenna for the UH-1 aircraft. GRA

N86-29152*# California Polytechnic State Univ., San Luis Obispo. Dept. of Aeronautical Engineering.
FLOW DIRECTION MEASUREMENT CRITERIA AND TECHNIQUES PLANNED FOR THE 40- BY 80-/80- X 120-FOOT WIND TUNNEL INTEGRATED SYSTEMS TESTS Final Report, 1 Jan. 1984 - 31 Jul. 1985
P. T. ZELL, J. HOFFMANN, and D. R. SANDLIN Jul. 1985 71 p
(Contract GNCC2-278)
(NASA-CR-176969; NAS 1.26:176969) Avail: NTIS HC A04/MFA01 CSCL 20D

A study was performed in order to develop the criteria for the selection of flow direction indicators for use in the Integrated Systems Tests (ISTs) of the 40 by 80/80 by 120 Foot Wind Tunnel System. The problems, requirements, and limitations of flow direction measurement in the wind tunnel were investigated. The locations and types of flow direction measurements planned in the facility were discussed. A review of current methods of flow direction measurement was made and the most suitable technique for each location was chosen. A flow direction vane for each location was chosen. A flow direction vane that employs a Hall Effect Transducer was then developed and evaluated for application during the ISTs. Author

N86-29159*# Stanford Univ., Calif. Dept. of Aeronautics and Astronautics.
FLOW PAST A FLAT PLATE WITH A VORTEX/SINK COMBINATION
N. J. MOURTOS Sep. 1984 51 p Previously announced as N85-25215
(Contract NCC2-149)
(NASA-CR-176908; NAS 1.26:176908; JIAA-TR-58) Avail: NTIS HC A04/MF A01 CSCL 20D

An attempt was made to model the so called leading edge vortex which forms over the leading edge of delta wings at high angles of attack. A simplified model was considered, namely that of a two-dimensional, inviscid, incompressible steady flow around a flat plate at an angle of attack with a stationary vortex detached on top, as well as a sink to simulate the strong spanwise flow. The results appear to agree qualitatively with experiments. A comparison was also made between the lift and the drag of this model and the corresponding results for two classical solutions: (1) that of totally attached flow over the plate with the Kutta condition satisfied at the trailing edge only: and (2) the Helmholtz solution of totally separated flow over the plate. M.G.

N86-29173# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France). Fluid Dynamics Panel.
SHOCK-WAVE BOUNDARY LAYER INTERACTIONS
J. DELERY (Office National d'Etudes et de Recherches Aeronautiques, Paris, France), J. G. MARVIN (National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.), and E. RESHOTKO (Case Western Reserve Univ., Cleveland, Ohio) Feb. 1986 223 p
(AGARD-AG-280; ISBN-92-835-1519-6) Avail: NTIS HC A10/MF A01

Presented is a comprehensive, up-to-date review of the shock-wave boundary-layer interaction problem. A detailed physical description of the phenomena for transonic and supersonic speed regimes is given based on experimental observations, correlations, and theoretical concepts. Approaches for solving the problem are then reviewed in depth. Specifically, these include: global methods developed to predict sudden changes in boundary-layer properties; integral or finite-difference methods developed to predict the continuous evolution of a boundary-layer encountering a pressure field induced by a shock wave; coupling methods to predict entire flow fields; analytical methods such as multi-deck techniques; and finite-difference methods for solving the time-dependent Reynolds-averaged Navier-Stokes equations used to predict the development of entire flow fields. Examples are presented to illustrate the status of the various methods and some discussion is devoted to delineating their advantages and shortcomings.

Reference citations for the wide variety of subject material are provided for readers interested in further study. Author

N86-29198*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
EVALUATION OF A QUARTZ BOURDON PRESSURE GAGE OF WIND TUNNEL MACH NUMBER CONTROL SYSTEM APPLICATION
W. G. CHAPIN Jul. 1986 19 p
(NASA-TM-88991; NAS 1.15:88991) Avail: NTIS HC A02/MF A01 CSCL 14B

A theoretical and experimental study was undertaken to determine the feasibility of using the National Transonic Facility's high accuracy Mach number measurement system as part of a closed loop Mach number control system. The theoretical and experimental procedures described are applicable to the engineering design of pressure control systems. The results show that the dynamic response characteristics of the NTF Mach number gage (a Ruska DDR-6000 quartz absolute pressure gage) coupled to a typical length of pressure tubing were only marginally acceptable within a limited range of the facility's total pressure envelope and could not be used in the Mach number control system. Author

N86-29218# Lockheed-California Co., Burbank.
DEVELOPMENT OF AN OPERATING PROFILE FOR AIRCRAFT TIRES Final Report
P. DURUP, M. GAMON, S. BOBO (Transportation Systems Center, Cambridge, Mass.), and S. K. CLARK (Michigan Univ., Ann Arbor.) Jun. 1986 103 p
(Contract DTRS57-80-C-00190)
(FAA/CT-85-32) Avail: NTIS HC A06/MF A01

The procedures of analysis and dynamometer testing that were used to develop data and supporting technology for improving the maintenance and continued airworthiness of civil aircraft tires are described. As related to the inspection, retread and repair of aircraft tires under Advisory Circular AC 145-41, improved criteria which characterize typical tire operating environments and operating scenarios (associated with long range, medium range, and short haul transport airplanes) are defined. Based upon these criteria and scenarios which include tire loading, temperature, and roll distances, means to assess tire fatigue life were developed. Results of this effort may be used for the identification of in-service acceptance criteria and prescribed retread limits. Author

N86-29236# Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France). Structures and Materials Panel.
AIRCRAFT AND BEARING TRIBOLOGICAL SYSTEMS
Loughton, England Feb. 1986 232 p Meeting held in San Antonio, Tex., 22-26 Apr. 1985
(AGARD-CP-394; ISBN-92-835-1509-9) Avail: NTIS HC A11/MF A01

Advances in aircraft gear and bearing tribology are discussed. Future trends and problems, gear and bearing materials, and lubricants are discussed.

N86-29238# Schaefer (Georg) and Co., Schweinfurt (West Germany).
EFFECTS OF UNFAVORABLE ENVIRONMENTAL CONDITIONS ON THE SERVICE LIFE OF JET ENGINE AND HELICOPTER BEARINGS
H. K. LOROESCH *In* AGARD Aircraft and Bearing Tribological Systems 9 p Feb. 1986
Avail: NTIS HC A11/MF A01

Aircraft bearings normally operate at high speeds and have to meet demanding reliability requirements. If conventional guidelines for their design are used, the resultant stresses are low. The stresses are particularly low if compared to those customarily applied in testing rolling fatigue. Potential fatigue life, the influence of plastic deformation in the raceways, the influence of surface damage and loading, service life under favorable lubricating conditions, achievable fatigue life at loads above the endurance limit, and the influence of contamination are discussed. Author

N86-29239# Motoren- und Turbinen-Union Muenchen G.m.b.H. (West Germany).
AERO-ENGINE GEARS: MANUFACTURING CRACKS AND THEIR EFFECT ON OPERATION
J. SPECHT *In* AGARD Aircraft and Bearing Tribological Systems 10 p Feb. 1986
Avail: NTIS HC A11/MF A01

The effect of cracks in gear splines is discussed. After black-oxidising of case-hardened gears, stress corrosion cracking may occur. This was determined from damage analysis of cracked gears of flight engines and from sample testing. Besides design measures to reduce operational stresses, corrective action may be in the form of modified manufacturing procedures and improved crack inspection. Author

N86-29240# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Stuttgart (West Germany). Inst. for Technical Physics.
TRIBOLOGY IN AIRCRAFT SYSTEMS: BASIC PRINCIPLES AND APPLICATIONS
E. JANTZEN and V. BUCK *In* AGARD Aircraft and Bearing Tribological Systems 13 p Feb. 1986
Avail: NTIS HC A11/MF A01

The historical origin of the name tribology is outlined. The trends for the next two decades are reviewed: reduction of fuel consumption, improvement of the ratio of specific output to weight, reduction of maintenance, and further improvement of safety. Then the consequences from these trends are outlined with respect to research in tribology. The current status of research is sketched and some unsolved problems are discussed: interaction of material/lubricant in areas with mixed friction (reaction layers); interaction of material/lubricant in the hydrodynamic region; friction and wear of synthetic bearings with and without lubrication; friction, wear and service time if solid lubricants are used; and topographical features of surfaces. Many government sponsored research to gain the wide spread of basic knowledge necessary for new and better solutions. Author

N86-29241# Schaefer (Georg) and Co., Schweinfurt (West Germany).
DESIGN AND CALCULATION OF HIGH SPEED ENGINE BEARINGS
H. J. KOEBER *In* AGARD Aircraft and Bearing Tribological Systems 12 p Feb. 1986
Avail: NTIS HCA11/MF A01

New aspects in design and calculation of high speed ball and roller bearings are discussed in as much as they affect bearing performance in the speed range of DxN = 3.0 x 1 million min-1 and beyond. For roller bearings the guide flange to roller end configuration as well as roller excursion within the cage pocket are linked to the phenomena of skewing and skidding. The need for under-race-lubrication in small diameter engine bearings is derived from this and a special solution (integral scoop) is shown along with related performance data. The influence of incorporating state of the art rolling elements made of silicon nitride on the design and calculation of high speed ball and roller bearings is shown taking into account hardness, density, Young's modulus and the Poisson ratio. Increase speeds coupled with additional design features being incorporated (such as lubrication holes, grooves, slots) require that inner rings of improved fracture toughness be developed with existing materials of known properties thus supplementing the material development activities already under way. Author

N86-29243# KHD Luftfahrttechnik G.m.b.H., Oberursel (West Germany).
MULTIFUNCTIONAL REQUIREMENTS FOR A GEARBOX SECONDARY POWER SYSTEM IN A MODERN FIGHTER AIRCRAFT AND ITS COMPONENTS AND INTERFACE REQUIREMENTS
M. PUCHER *In* AGARD Aircraft and Bearing Tribological Systems 14 p Feb. 1986
Avail: NTIS HC A11/MF A01

The basic task of the gearbox in a Secondary Power System (SPS) of an aircraft is to provide and distribute mechanical energy from the Auxiliary Power Unit (APU) or from the Main Engine (ME) to the accessories, e.g., generators, hydraulic pumps and fuel pumps. The complexity as well as the functional facilities increase by incorperating further functional requirements such as main engine start, cross drive operation between redundant systems with the associated control devices, including oil supply to the accessories into the gearbox oil system. The Tornado-SPS is one of the most modern systems flying today. The system shows a high reliability although the aircraft has been in service for only a few years. The experience gained with major components like gearbox housing, gearing, freewheel clutches, dry friction cluthes and components of the oil system is reported. Some aspects from this experience are given for the design of gearboxes for future secondary power systems. Author

N86-29271*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
EXPERIMENTAL CLASSICAL FLUTTER REESULTS OF A COMPOSITE ADVANCED TURBOPROP MODEL
O. MEHMED and K. R. V. KAZA Jul. 1986 18 p Presented at the Bisplinghoff Memorial Symposium on Recent Trends in Aeroelasticity, Structures and Structural Dynamics, Gainesville, Fla., 6-7 Feb., 1986; sponsored by Fla. Univ.
(NASA-TM-88792; E-3127; NAS 1.15:88792) Avail: NTIS HC A02/MF A01 CSCL 20K

Experimental results are presented that show the effects of blade pitch angle and number of blades on classical flutter of a composite advanced turboprop (propfan) model. An increase in the number of blades on the rotor or the blade pitch angle is destablizing which shows an aerodynamic coupling or cascade effect between blades. The flutter came in suddenly and all blades vibrated at the same frequency but at different amplitudes and with a common predominant phase angle between consecutive blades. This further indicates aerodynamic coupling between blades. The flutter frequency was between the first two blade normal modes, signifying an aerodynamic coupling between the normal modes. Flutter was observed at all blade pitch angles from small to large angles-of-attack of the blades. A strong blade response occurred, for four blades at the two-per-revolution (2P) frequency, when the rotor speed was near the crossing of the flutter mode frequency and the 2P order line. This is because the damping is low near the flutter condition and the interblade phase angle of the flutter mode and the 2P response are the same.
Author

N86-29279# Office National d'Etudes et de Recherches Aerospatiales, Paris (France). Dir. Scientifique de la Resistance des Structures.
BOUNDARY LAYER MODEL TO COMPUTE THE EDGE EFFECTS IN STRATIFIED COMPOSITE PLATES Final Report [UN MODELE DE COUCHE LIMITE POUR LE CALCUL DES EFFETS DE BORD DANS LES PLAQUES STRATIFIEES COMPOSITES]
R. GIRARD Oct. 1985 21 p In FRENCH
(Contract DRET-84-34-001)
(ONERA-RT-7/3542-RY-041-R; ESA-86-97202) Avail: NTIS HC A02/MF A01

The limit conditions are used to modify the classical solution to satisfy the three dimensional conditions, in order to study a complex stress distribution that could result in composite layer delaminating. The general equations of a zero order model are presented. They reveal the interface complex conditions, which are theoretically simple to solve. The practical solutions are not simple, and the particular cases for which a comparison with analytical solutions is possible, are discussed. ESA

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GEOSCIENCES

Includes geosciences (general); earth resources; energy production and conversion; environment pollution; geophysics; meteorology and climatology; and oceanography.

A86-40555
THE CALCULATION OF THE ENTROPY DISTRIBUTION ALONG CLOUD TRAVERSES USING AIRCRAFT MEASUREMENTS
TH. HAUF and J. WEIDNER (DFVLR, Institut fuer Physik der Atmosphaere, Oberpfaffenhofen, West Germany) Meteorologische Rundschau (ISSN 0026-1211), vol. 39, April 1986, p. 33-36. refs

The entropy distribution along horizontal cloud traverses is calculated using aircraft data of high spatial resolution. For the first time, absolute values of entropy inside and outside of clouds are presented. The entropy trace is nearly identical with the humidity trace. Strong fluctuations of entropy are found at the cloud edges. Temperature fluctuations are negatively correlated with the humidity fluctuations and tend to smooth the entropy distribution outside the clouds. The variations in the fields of liquid water content and pressure have negligible effect on the entropy. Results are discussed using the entropy state function. Author

A86-41035#
TAMING THE KILLER WIND SHEAR
E. J. LERNER Aerospace America (ISSN 0740-722X), vol. 24, May 1986, p. 38-40, 42.

Technical difficulties and bureaucratic hurdles are considered that must be overcome before timely wind shear warnings are routinely available for pilots. The circumstances of the downdraft/microburst wind shear conditions that caused the August 1985 crash of an L-1011 at Dallas/Fort Worth are examined. That crash could have been averted with a timely warning, but the existing system could only provide an alert 1-2 minutes too late. The CLAWS (classify, locate, and avoid wind shear) system - using a single Doppler radar and a beefed up system of anemometers, was a demonstration system developed by the FAA, but it was terminated for budgetary reasons. Lincoln Labs is working on a system with advanced features: ground clutter suppression, automated recognition of microburst and warning issuance. Other organizations working on the problem include NOAA, the Air Force, Sperry, and Raytheon. Real time prediction is still a problem. Improved wind shear safety over the short term depends on Doppler terminal radars and it remains to be seen whether recent crashes will pry from Congress and the Office of Management and Budget the half-billion dollars needed to get them on the air. D.H.

N86-28588# Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Oberpfaffenhofen (West Germany). Inst. fuer Physik der Atmosphaere.
PROCESSING AND METEOROLOGICAL EVALUATION OF RESEARCH FLIGHTS WITH DFVLR MOTOR GLIDERS USING THE SOFTWARE PACKAGE RAMF
J. M. HACKER Jan. 1985 69 p In GERMAN; ENGLISH summary
(DFVLR-FB-85-57; ISSN-0171-1342; ESA-86-96877) Avail: NTIS HC A04/MF A01; DFVLR, Cologne DM 19

The procedures developed for the processing and simple meteorological reduction of data from measuring flights are summarized. Philosophy, construction, and utilization of the software package RAM (routines for the evaluation of meteorological research flights) are described. The routines and the methods for data evaluation are presented and clarified by examples. The accuracy of the derived variables is estimated.
ESA

N86-29466*# Stanford Univ., Calif. Dept. of Aeronautics and Astronautics.
A SIMPLIFIED MODEL OF THE TURBULENT MICROBURST
L. ROBERTS and T. WAN Mar. 1985 27 p
(Contract NCC2-270)
(NASA-CR-177108; NAS 1.26:177108; SU-JIAA-TR-59) Avail: NTIS HC A03/MF A01 CSCL 04B

A simple model was developed to describe the low altitude shear associated with a microburst (or small downburst) in the atmosphere. Such microbursts are thought to be the cause of convective radial flows near the ground which represent potentially hazardous conditions to aircraft during approach and landing. Closed form solutions are presented for the equations of mass, momentum, and thermal energy to give the spreading rate of the microburst and the velocity and temperature decay due to turbulence. An analysis of the impact of the microburst and its radial spreading over the ground is given and illustrated examples are provided. The solution for the downward and outward wind velocities are given in terms of simple dimensionless algebraic parameters which can be computed readily in realtime during a piloted simulation of an aircraft flying through a microburst.
Author

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LIFE SCIENCES

Includes life sciences (general); aerospace medicine; behavioral sciences; man/system technology and life support; and planetary biology.

A86-41782* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.
DISPLACEMENT THRESHOLDS IN CENTRAL AND PERIPHERAL VISION DURING TRACKING
R. F. HAINES (NASA, Ames Research Center, Moffett Field, CA) Aviation, Space, and Environmental Medicine (ISSN 0095-6562), vol. 57, June 1986, p. 548-554. refs

The effects of stimulus duration and angular velocity on a subject's judgment of displacement threshold are examined. Twenty-six male subjects between 17-45 years with uncorrected 20:20 distance acuity and normal color perception and stereopsis studied a series of forced choice, paired comparison trials in which a long, thin, collimated horizontally oriented line moved downward through 12 angles ranging from 0.6-60 arcmin and judged which stimulus moved in each pair. The displacements were produced by 0.25, 0.5, 1, 2, and 4 sec stimulus duration and 2.5, 5, 10, and 15 deg/sec angular rates. Stimulus velocity, stimulus duration, mean threshold displacement, and mean confidence results are analyzed. It is observed that displacement judgment accuracy is increased with increasing stimulus duration. The data are compared with the results of Johnson and Leibowitz (1976) and Johnson and Scobey (1982), and good correlation with the Johnson and Leibowitz data is detected. The data reveal that threshold is based on a constant stimulus velocity over this range of durations and velocities. The data are applicable to the study of the final approach to landing of medium and large commercial jet aircraft. I.F.

N86-29508*# Georgia Inst. of Tech., Atlanta. Center for Man-Machine Systems Research.
PILOT INTERACTION WITH AUTOMATED AIRBORNE DECISION MAKING SYSTEMS Semiannual Progress Report, Mar. - Aug. 1984
W. B. ROUSE, J. M. HAMMER, N. M. MORRIS, A. E. KNAEUPER, E. N. BROWN, C. M. LEWIS, and W. C. YOON Aug. 1984 45 p
(Contract NAG2-123)
(NASA-CR-177002; NAS 1.26:177002) Avail: NTIS HC A03/MF A01 CSCL 05H

Two project areas were pursued: the intelligent cockpit and human problem solving. The first area involves an investigation of the use of advanced software engineering methods to aid aircraft crews in procedure selection and execution. The second area is focused on human problem solving in dynamic environments, particulary in terms of identification of rule-based models land alternative approaches to training and aiding. Progress in each area is discussed. B.G.

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MATHEMATICAL AND COMPUTER SCIENCES

Includes mathematical and computer sciences (general); computer operations and hardware; computer programming and software; computer systems; cybernetics; numerical analysis; statistics and probability; systems analysis; and theoretical mathematics.

A86-40760
COMPUTER AIDED CONTROL SYSTEM DESIGN USING A MULTIOBJECTIVE OPTIMIZATION APPROACH
P. J. FLEMING (North Wales, University College, Bangor, Wales) and A. P. PASHKEVICH (Minskii Radiotekhnicheskii Institut, Minsk, Belorussian SSR) IN: Control 85; Proceedings of the International Conference, Cambridge, England, July 9-11, 1985. Volume 1 . London/New York, Institution of Electrical Engineers/IEE Inspec, 1985, p. 174-179. refs

Multiobjective optimization attempts to simultaneously optimize several objectives with respect to the free controller parameters. An evaluation is presently made of multiobjective optimization strategies, with attention to the goal-attainment method; this is applied to three different examples in order to demonstrate the technique: (1) a case highlighting the value of multiobjective optimization in the generation of tradeoff surfaces; (2) a multiregime linear quadratic regulator problem; and (3) the design of a cascade compensator, subject to standard control specifications. Plans for the development of the multiobjective optimization approach as a computer-aided control system design tool are discussed. O.C.

A86-40762
THE DESIGN AND IMPLEMENTATION OF MULTIVARIABLE VARIABLE STRUCTURE CONTROL SYSTEMS
C. M. DORLING and A. S. I. ZINOBER (Sheffield, University, England) IN: Control 85; Proceedings of the International Conference, Cambridge, England, July 9-11, 1985. Volume 1 . London/New York, Institution of Electrical Engineers/IEE Inspec, 1985, p. 264-269. refs

The design of the sliding mode in a nominally linear variable structure control system (VSCS) may be completed independently of the form of the actual control functions selected. After defining the nominally linear time-varying and uncertain system that is to be controlled, some of the options available in the design of a stable sliding mode are considered; a canonical form is employed for the design of the hyperplane matrix and the control structure. Attention is given to the eigenstructure assignment method for the design of the sliding mode, and the design of the controller that ensures correct operation in the two stages of the VSCS is outlined. O.C.

A86-40774
AN EXPERT SYSTEM FOR CONTROL SYSTEM DESIGN
T. L. TRANKLE and L. Z. MARKOSIAN (Systems Control Technology, Inc., Palo Alto, CA) IN: Control 85; Proceedings of the International Conference, Cambridge, England, July 9-11, 1985. Volume 2 . London/New York, Institution of Electrical Engineers/IEE Inspec, 1985, p. 495-499. Research supported by the McDonnell Aircraft Corp. refs

Work in progress to develop knowledge-based expert systems to supervise adaptive control systems in real time is reported. The overall structure of an expert adaptive controller is outlined, and a detailed description is given of one of its components: the feedback control system designer. This designer uses a planning expert system to supervise the application of computer-aided control system design (CACSD) algorithms. The design of an aircraft feedback control system is mentioned as an example. B.J.

A86-41934
TWO APPROACHES TO HYPERPLANE DESIGN IN MULTIVARIABLE VARIABLE STRUCTURE CONTROL SYSTEMS
C. M. DORLING (Sheffield, University, England) and A. S. I. ZINOBER (Topexpress, Ltd., Cambridge, England) International Journal of Control (ISSN 0020-7179), vol. 44, July 1986, p. 65-82. refs

The design of a stable sliding mode in a variable structure control system is considered in detail. A certain canonical form for the nominal linear system is described, with particular reference to a numerical implementation. Two methods of determining the subspace within which ideal sliding motion occurs are presented, these methods being based on quadratic minimization and eigenstructure assignment. A control structure ensuring the attainment of the sliding mode is summarized, along with a practical method of removing the chatter motion associated with variable structure systems. An example illustrating the methods described is included. Author

A86-42860
ROBUST SIMPLIFIED ADAPTIVE CONTROL FOR A CLASS OF MULTIVARIABLE CONTINUOUS-TIME SYSTEMS
I. BAR-KANA (Rafael Armament Development Authority, Haifa, Israel) and H. KAUFMAN (Rensselaer Polytechnic Institute, Troy, NY) IN: Conference on Decision and Control, 24th, Fort Lauderdale, FL, December 11-13, 1985, Proceedings. Volume 1 . New York, Institute of Electrical and Electronics Engineers, Inc., 1985, p. 141-146. refs

This paper presents a simple and robust adaptive control algorithm for a class of multivariable continuous-time linear systems. Boundedness of all values involved in the adaptation process is guaranteed in the presence of parasitic disturbances and dynamics provided that the controlled plant is stabilizable via unknown static output feedback. The usual need of prior knowledge about the order of the plant and about the pole-excess is also eliminated. Although these techniques can be generalized and their applicability can be extended to systems that need dynamic feedback in order to achieve stability, the present algorithm has its own importance, due to its extreme simplicity of implementation that may facilitate application of adaptive control in realistic complex control systems with unknown parameters. Author

A86-42871
NEW APPLICATIONS OF MU TO REAL-PARAMETER VARIATION PROBLEMS
B. G. MORTON (Honeywell Systems and Research Center, Minneapolis, MN) IN: Conference on Decision and Control, 24th, Fort Lauderdale, FL, December 11-13, 1985, Proceedings. Volume 1 . New York, Institute of Electrical and Electronics Engineers, Inc., 1985, p. 233-238.

The structured singular value (SSV) has been used in recent studies of the robust stability of feedback systems subject to real-parameter variations. In this paper, the results obtained when some new upper-bounds on the SSV for real-parameters were used in two studies of flight control systems are summarized. The perturbation structure for higher rank perturbations is discussed and the issue of lower-bounds for the SSV in the real-parameter problem is considered. A new theoretical result relevant to lower-bounds in a special case is given. Author

A86-42877
A DIFFERENTIAL DYNAMIC PROGRAMMING METHOD WITH AN ABRUPT PENALTY INTEGRAND FOR SOLVING TOLERANCE PROBLEMS
B. JARMARK (SAAB-Scania AB, Linkoping, Sweden) IN: Conference on Decision and Control, 24th, Fort Lauderdale, FL, December 11-13, 1985, Proceedings. Volume 1 . New York, Institute of Electrical and Electronics Engineers, Inc., 1985, p. 287-289.

A nonlinear optimal control problem is considered in respect to a new class of performance index. The problem is to control an output function to be inside a prescribed tolerance zone. When inside the zone, this will result in a favorable cost contribution. When outside there will be no contribution. The numerical optimization algorithm used is a modified differential dynamic programming method. The method is expanded to this class of cost functionals. An example illustrates the difference in using the new cost functional and two other commonly used cost functionals. Author

A86-42899
A COVARIANCE CONTROL THEORY
A. F. HOTZ and R. E. SKELTON (Purdue University, West Lafayette, IN) IN: Conference on Decision and Control, 24th, Fort Lauderdale, FL, December 11-13, 1985, Proceedings. Volume 1 . New York, Institute of Electrical and Electronics Engineers, Inc., 1985, p. 552-557. refs

A theory is presented for the design of linear feedback controllers in order to arrive at a closed loop system that achieves a specified state covariance. After defining the necessary and sufficient conditions for the existence of constant linear feedback controllers that assign a specified state covariance to the closed loop system, the resulting set of feedback gain matrices are identified. It is shown that when existence is verified, the set of solutions is in general very large. Author

A86-42912
EIGENSTRUCTURE ASSIGNMENT, EIGENSENSITIVITY, AND FLIGHT CONTROL DESIGN
K. M. SOBEL (Lockheed-California Co., Burbank) and E. Y. SHAPIRO (HR Textron, Inc., Valencia, CA) IN: Conference on Decision and Control, 24th, Fort Lauderdale, FL, December 11-13, 1985, Proceedings. Volume 1 . New York, Institute of Electrical and Electronics Engineers, Inc., 1985, p. 658, 659.

A sensitivity measure which describes changes in the damping of complex conjugate eigenvalues due to changes in the entries of the closed loop system matrix is introduced. An example is presented to illustrate the application of eigenstructure assignment with damping sensitivity reduction to the design of a flight control system. Author

A86-42957
AN ANALYSIS OF A FOUR STATE MODEL FOR PURSUIT-EVASION GAMES
A. J. CALISE and X.-M. YU (Drexel University, Philadelphia, PA) IN: Conference on Decision and Control, 24th, Fort Lauderdale, FL, December 11-13, 1985, Proceedings. Volume 2 . New York, Institute of Electrical and Electronics Engineers, Inc., 1985, p. 1119-1121. refs

An analysis is given for a four state model useful in medium range air-combat analysis. The problem is formulated as a differential game of degree, with capture time as the performance index. The model is representative of a three-dimensional pursuit-evasion game between two aircraft at medium to large ranges. A complete and exact characterization of the optimal paths and controls is given for arbitrary aerodynamic and propulsion models. Author

A86-42996
INTEGRATED CONTROL - A DECENTRALIZED APPROACH
A. EMAMI-NAEINI, R. P. ANEX, and S. M. ROCK (Systems Control Technology, Inc., Palo Alto, CA) IN: Conference on Decision and Control, 24th, Fort Lauderdale, FL, December 11-13, 1985, Proceedings. Volume 3 . New York, Institute of Electrical and Electronics Engineers, Inc., 1985, p. 1836-1841. refs
(Contract F33615-82-C-2214)

A decentralized, robust, multivariable controls method is described for the functional integration of subsystems in large-scale systems characterized by dynamic coupling among subsystem elements. In an integrated environment, a decentralized control structure reduces the complexity of the control by distributing the control authority to local controllers. The method relies upon generation of a set of control design specifications for the subsystems. The subsystem designers are provided with design specifications that provide for the integration of control functions. If the subsystem designers can satisfy these specifications, successful integration of the subsystem controls is guaranteed. The specifications are in terms of stability and performance robustness constraints in the frequency domain. The results are applied to an integrated flight-propulsion control example.
Author

A86-43000* Connecticut Univ., Storrs.
DUAL CONTROL AND PREVENTION OF THE TURN-OFF PHENOMENON IN A CLASS OF MIMO SYSTEMS
P. MOOKERJEE, Y. BAR-SHALOM, and J. A. MOLUSIS (Connecticut, University, Storrs) IN: Conference on Decision and Control, 24th, Fort Lauderdale, FL, December 11-13, 1985, Proceedings. Volume 3 . New York, Institute of Electrical and Electronics Engineers, Inc., 1985, p. 1888-1893. refs
(Contract NAG2-318; AF-AFOSR-84-0112)

A recently developed methodology of adaptive dual control based upon sensitivity functions is applied here to a multivariable input-output model. The plant has constant but unknown parameters. It represents a simplified linear version of the relationship between the vibration output and the higher harmonic control input for a helicopter. The cautious and the new dual controller are examined. In many instances, the cautious controller is seen to turn off. The new dual controller modifies the cautious control design by numerator and denominator correction terms which depend upon the sensitivity functions of the expected future cost and avoids the turn-off and burst phenomena. Monte Carlo simulations and statistical tests of significance indicate the superiority of the dual controller over the cautious and the heuristic certainity equivalence controllers. Author

A86-43003
TRANSFER OF ALIGNMENT AND CALIBRATION OF MULTIPLE SENSORS IN FLEXIBLE SYSTEMS
H. C. SALZWEDEL and K. M. KESSLER (Systems Control Technology, Inc., Palo Alto, CA) IN: Conference on Decision and Control, 24th, Fort Lauderdale, FL, December 11-13, 1985, Proceedings. Volume 3 . New York, Institute of Electrical and Electronics Engineers, Inc., 1985, p. 1932-1937. refs

A method for the transfer aligment and calibration of sensors in flexible systems is presented. Flexible systems are represented by high order differential equations and reduced in dimension by model order reduction techniques. Both disturbability of alignment errors by control and disturbance inputs are considered. The reduced order model is decomposed by non-symmetric Riccati decomposition into states that directly and indirectly affect alignment errors. A transfer alignment and calibration filter with control feedthrough is developed and demonstrated for the example of a large flexible aircraft model in turbulence. Author

A86-43387
IDENTIFICATION OF FREQUENCY CHARACTERISTICS DURING BENCH TESTS [IDENTIFIKATSIIA CHASTOTNYKH KHARAKTERISTIK PRI STENDOVYKH ISPYTANIIAKH]
I. KH. SADYKOV Aviatsionnaia Tekhnika (ISSN 0579-2975), no. 1, 1986, p. 47-52. In Russian.

Consideration is given to the identification of the frequency characteristics during bench tests of aircraft control systems using an analysis of experimental values of the input and output signals. It is shown that, for nonzero values of the initial conditions of the recorded signals, the determination of the frequency characteristics necessarily involves the identification of the parameters of a model of the test object. Algorithms for solving this problem are presented. B.J.

N86-28359# Royal Signals and Radar Establishment, Malvern (England).
MIL-DAP: ITS ARCHITECTURE AND ROLE AS A REAL TIME AIRBORNE DIGITAL SIGNAL PROCESSOR
P. SIMPSON, J. B. G. ROBERTS, and B. C. MERRIFIELD *In* AGARD The Impact of Very High Performance Integrated Circuits on Radar, Guidance and Avionics Systems 18 p Aug. 1985
Avail: NTIS HC A17/MF A01

Prototypes of a highly programmable digital processor, Mil-DAP, operating in excess of 300 MOPS and occupying less than a cubic foot will be available in 1985. Its architecture consisting of a large array of processing elements, controlled by a single control unit operating in a Single Instruction Muliple Data (SIMD) mode is described in some detail, including the provision of fast data input-output (up to 40 MBytes/sec), data buffering and programmable data reformation such as corner turning. Two programming languages exist; an assembler language for high efficiency and a higher level parallel form of FORTRAN. The ease of use of both these parallel languages is demonstrated with reference to simple examples. Mil-DAP's performance, size, weight and power consumption suit it well to the wide range of applications encountered in an avionics environment. For example, multimode, radar signal processing incorporating spectral analysis, constant false alarm rate processing and ambiguity resolution; speech recognition as in a voice driven cockpit; electronic support measures where very high speed association and recognition of received pulse information is needed; and reconnaissance image processing, are all potential real time applications. Benchmarks for these are given. Author

N86-28628*# National Aeronautics and Space Administration, Washington, D.C.
NASA SUPERCOMPUTER SYSTEM TO BECOME AVAILABLE NATIONALLY
D. J. RAHN and P. W. WALLTER (National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.) 21 Jul. 1986 2 p
(NASA-NEWS-RELEASE-86-92; P86-10152) Avail: NASA Scientific and Technical Information Facility, P.O. Box 8752, B.W.I. Airport, Md. 21240 CSCL 09B

The most powerful supercomputer facility in the world, the Numerical Aerodynamic Simulation (NAS) system, will go on-line to scientists and engineers throughout the country on July 21, 1986. The NAS supercomputer complex will be linked with 27 remote locations across the country through a combination of high-speed terrestrail and satellite links. The Cray-2 supercomputer was installed as the main computational engine. The NAS CRAY-2 has a 256 million word memory (largest yet available) and can perform 250 million computations a second. The next generation superfast computer currently referred to as the HSP-2 (High Speed Processor-2) is expected to perform a billion computation a second. This will bring the NAS system closer to its near-term goal of having computer with a billion word memory and computational power of 4 billion calculations a second. The NAS system will be relocated to a new computational facility in late 1986 and will be fully operational in March 1987. B.G.

N86-28673# National Aerospace Lab., Amsterdam (Netherlands). Informatics Div.
THE USE OF MATHEMATICAL OPTIMIZATION TECHNIQUES BY THE DESIGNER
R. F. VANDENDAM 25 Jan. 1985 46 p In DUTCH; ENGLISH summary Presented at Congress on Computer Applications in Production and Engineering (CAPE) Nederland '85, Amsterdam, Netherlands, May 1985
(NLR-MP-85005-U; B8578430; ESA-86-96975) Avail: NTIS HC A03/MF A01

Mathematical optimization techniques in the design process and their use by designers are discussed. The principles underlying these techniques and the requirements for a flexible optimization system having a broad applicability are considered. Optimization techniques used in aeronautical engineering are reviewed and illustrated with the examples of the System for the Analysis and Constrainted Minimization of Induced Drag and Computational Aerodynamic Design-by-Optimization System. ESA

N86-29547*# Research Triangle Inst., Research Triangle Park, N.C.
AN EXPERIMENT IN SOFTWARE RELIABILITY Final Report
J. R. DUNHAM and J. L. PIERCE May 1986 62 p
(Contract NAS1-16489)
(NASA-CR-172553; NAS 1.26:172553; REPT-412U-2094-12; REPT-412U-2094-14) Avail: NTIS HC A04/MF A01 CSCL 09B

The results of a software reliability experiment conducted in a controlled laboratory setting are reported. The experiment was undertaken to gather data on software failures and is one in a series of experiments being pursued by the Fault Tolerant Systems Branch of NASA Langley Research Center to find a means of credibly performing reliability evaluations of flight control software. The experiment tests a small sample of implementations of radar tracking software having ultra-reliability requirements and uses n-version programming for error detection, and repetitive run modeling for failure and fault rate estimation. The experiment results agree with those of Nagel and Skrivan in that the program error rates suggest an approximate log-linear pattern and the individual faults occurred with significantly different error rates. Additional analysis of the experimental data raises new questions concerning the phenomenon of interacting faults. This phenomenon may provide one explanation for software reliability decay. M.G.

N86-29579*# Syracuse Univ., N. Y. Dept. of Mechanical and Aerospace Engineering.
LINEAR AND NONLINEAR DYNAMIC ANALYSIS OF REDUNDANT LOAD PATH BEARINGLESS ROTOR SYSTEMS Status Report
V. R. MURTHY Dec. 1985 94 p
(Contract NAG2-306)
(NASA-CR-177098; NAS 1.26:177098) Avail: NTIS HC A05/MF A01 CSCL 12A

The bearingless rotorcraft offers reduced weight, less complexity and superior flying qualities. Almost all the current industrial structural dynamic programs of conventional rotors which consist of single load path rotor blades employ the transfer matrix method to determine natural vibration characteristics because this method is ideally suited for one dimensional chain like structures. This method is extended to multiple load path rotor blades without resorting to an equivalent single load path approximation. Unlike the conventional blades, it isk necessary to introduce the axial-degree-of-freedom into the solution process to account for the differential axial displacements in the different load paths. With the present extension, the current rotor dynamic programs can be modified with relative ease to account for the multiple load paths without resorting to the equivalent single load path modeling. The results obtained by the transfer matrix method are validated by comparing with the finite element solutions. A differential stiffness matrix due to blade rotation is derived to facilitate the finite element solutions. Author

N86-29580*# Massachusetts Inst. of Tech., Cambridge.
MULTIVARIABLE CONTROL SYSTEMS WITH SATURATING ACTUATORS ANTIRESET WINDUP STRATEGIES
P. KAPASOURIS and M. ATHANS May 1985 6 p Sponsored in part by General Electric Co.
(Contract NAG2-297; NGL-22-009-124)
(NASA-CR-177100; NAS 1.26:177100; LIDS-P-1461) Avail: NTIS HC A02/MF A01 CSCL 12A

Preliminary, promising, results for introducing antireset windup (ARW) properties in multivariable feedback control systems with multiple saturating actuator nonlinearities and integrating actions are presented. The ARW method introduces simple nonlinear feedback around the integrators. The multiloop circle criterion is used to derive sufficient conditions for closed-loop stability that employ frequency-domain singular value tests. The improvement in transient response due to the ARW feedback is demonstrated using a 2-input 2-outpurt control system based upon F-404 jet engine dynamics. Author

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PHYSICS

Includes physics (general); acoustics; atomic and molecular physics; nuclear and high-energy physics; optics; plasma physics; solid-state physics; and thermodynamics and statistical physics.

A86-41689*# Missouri Univ., Rolla.
MODELING WIND TUNNEL EFFECTS ON THE RADIATION CHARACTERISTICS OF ACOUSTIC SOURCES
W. EVERSMAN (Missouri-Rolla, University, Rolla) and K. J. BAUMEISTER (NASA, Lewis Research Center, Cleveland, OH) Journal of Aircraft (ISSN 0021-8669), vol. 23, June 1986, p. 455-463. Previously cited in issue 05, p. 641, Accession no. A85-16104. refs

A86-43038* Clemson Univ., S.C.
COLLOCATION FOR AN INTEGRAL EQUATION ARISING IN DUCT ACOUSTICS
W. F. MOSS (Clemson University, SC) Journal of Computational Physics (ISSN 0021-9991), vol. 64, June 1986, p. 443-458. refs
(Contract NAS1-17130; NAS1-16394)

A mathematical model is developed to describe the effect of aircraft-engine inlet geometry on the reflected and radiated acoustic field without flow, as studied experimentally using a spinning-mode synthesizer by Silcox (1983). The acoustic pressure in the inlet interior and exterior is modeled by a pure cylindrical azimuthal mode for the Helmholtz equation with hardwall boundary and by the Helmholtz equation and the radiation condition at infinity, respectively. The analytical approach to the solution of the resulting boundary-value problem and the program implementation are explained; numerical results are presented in tables and graphs; and the uniqueness of the problem is demonstrated. T.K.

N86-28701*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
WIND-TUNNEL ACOUSTIC RESULTS OF TWO ROTOR MODELS WITH SEVERAL TIP DESIGNS
R. M. MARTIN and A. B. CONNOR Jul. 1986 191 p
(NASA-TM-87698; L-16081; NAS 1.15:87698) Avail: NTIS HC A09/MF A01 CSCL 20F

A three-phase research program has been undertaken to study the acoustic signals due to the aerodynamic interaction of rotorcraft main rotors and tail rotors. During the first phase, two different rotor models with several interchangeable tips were tested in the Langley 4- by 7-Meter Tunnel on the U.S. Army rotor model system. An extensive acoustic data base was acquired, with special emphasis on blade-vortex interaction (BVI) noise. The details of the experimental procedure, acoustic data acquisition, and reduction are documented. The overall sound pressure level

(OASPL) of the high-twist rotor systems is relatively insensitive to flight speed but generally increases with rotor tip-path-plane angle. The OASPL of the high-twist rotors is dominated by acoustic energy in the low-frequency harmonics. The OASPL of the low-twist rotor systems shows more dependence on flight speed than the high-twist rotors, in addition to being quite sensitive to tip-path-plane angle. An integrated band-limited sound pressure level, limited by 500 to 3000 Hz, is a useful metric to quantify the occurrence of BVI noise. The OASPL of the low-twist rotors is strongly influenced by the band-limited sound levels, indicating that the blade-vortex impulsive noise is a dominant noise source for this rotor design. The midfrequency acoustic levels for both rotors show a very strong dependence on rotor tip-path-plane angle. The tip-path-plane angle at which the maximum midfrequency sound level occurs consistently decreases with increasing flight speed. The maximum midfrequency sound level measured at a given location is constant regardless of the flight speed. Author

N86-28702*# Pennsylvania State Univ., University Park. Dept. of Physics.
EXPERIMENTAL STUDY USING NEARFIELD ACOUSTIC HOLOGRAPHY OF SOUND TRANSMISSION THROUGH FUSELAGE SIDEWALL STRUCTURES Final Report
J. D. MAYNARD 1986 70 p
(Contract NAG1-216)
(NASA-CR-177162; NAS 1.26:177162) Avail: NTIS HC A04/MF A01 CSCL 20A

The reduction of cabin noise in lightweight, propeller-driven aircraft is an especially difficult problem in noise control. Nearfield Acoustic Holography (NAH) was used to determine the mode of vibration and acoustic intensity for panels which differed in: construction (number of stiffening ribs, size of stifening ribs, construction material, and panel surface curvature); boundary support condition (free edge condition or clamped edge condition); and mode of excitation (structural-borne forces or airborne forces). The different samples of aircraft panels are described and the measurement of the natural response frequencies was discussed under various boundary support and excitation conditions. The results of the NAH measurements are presented. B.G.

N86-29630*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
MODELING THE EFFECTS OF WIND TUNNEL WALL ABSORPTION ON THE ACOUSTIC RADIATION CHARACTERISTICS OF PROPELLERS
K. J. BAUMEISTER and W. EVERSMAN (Missouri Univ., Rolla.) Jul. 1986 21 p Presented at the 10th Aeroacustics Conference, Seattle, Wash., 9-11 Jul. 1986; sponsored by AIAA
(NASA-TM-87333; E-2812; NAS 1.15:87333; AIAA-86-1876)
Avail: NTIS HC A02/MF A01 CSCL 20A

Finite element theory is used to calculate the acoustic field of a propeller in a soft walled circular wind tunnel and to compare the radiation patterns to the same propeller in free space. Parametric solutions are present for a 'Gutin' propeller for a variety of flow Mach numbers, admittance values at the wall, microphone position locations, and propeller to duct radius ratios. Wind tunnel boundary layer is not included in this analysis. For wall admittance nearly equal to the characteristic value of free space, the free field and ducted propeller models agree in pressure level and directionality. In addition, the need for experimentally mapping the acoustic field is discussed. Author

N86-29632*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
INTERACTION OF AIRBORNE AND STRUCTUREBORNE NOISE RADIATED BY PLATES. VOLUME 2: EXPERIMENTAL STUDY
M. C. MCGARY Jul. 1986 36 p
(NASA-TM-87747; NAS 1.15:87747) Avail: NTIS HC A03/MF A01 CSCL 20A

The interaction of airborne and structureborne noise radiated by aircaraft materials was studied. The results corroborate the findings of an earlier analytical study by showing that the noise radiation of vibrating plates due to combined airborne and structureborne inputs possesses a stong synergistic nature. The large influence of the interaction between the airborne and structureborne inputs was hitherto ignored by researchers of aircraft interior noise problems. Author

N86-29633*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.
INTERACTION OF AIRBORNE AND STRUCTUREBORNE NOISE RADIATED BY PLATES. VOLUME 1: ANALYTICAL STUDY
M. C. MCGARY Jul. 1986 61 p
(NASA-TM-87746; NAS 1.15:87746) Avail: NTIS HC A04/MF A01 CSCL 20A

The interaction of airborne and structureborne noise radiated by aircraft materials was examined. The theory and results of several computer simulations of the noise radiated by thin, isotropic, rectangular aluminum plates due to fully coherent combined acoustic and vibrational inputs is presented. The most significant finding was the extremely large influence that the relative phase between inputs has on the combined noise radiation of the plates. Phase dependent effects manifest themselves as cross terms in both the dynamic and acoustic portions of the analysis. Computer simulations show that these cross terms can radically alter the combined sound power radiated by plates constructed of aircraft-type materials. The results suggest that airborne-structureborne interactive effects could be responsible for a significant portion of the overall noise radiated by aircraft-type structures in the low frequency regime. This implies that previous analytical and experimental studies may have neglected an important physical phenomenon in the analayses of the interior noise of propeller dirven aircraft. Author

N86-29636# National Aerospace Lab., Amsterdam (Netherlands). Fluid Dynamics Div.
A STUDY ON THE TRANSMISSION OF SOUND THROUGH FLOW DUCTS OF VARYING CROSS SECTION
S. W. RIENSTRA 15 Oct. 1983 50 p
(Contract NIVR-311.4-1946)
(NLR-TR-83128-U; B8660348; ESA-86-97503) Avail: NTIS HC A03/MF A01

Sound propagation through axially varying ducts with mean flow is studied. Analytical theories for low and high frequencies are derived. A computer program for Nayfeh's (1980) wave envelope approach was tested to see if bottlenecks could be identified, what parameter range is attainable, and to what extent the classical uniform duct model produces satisfactory results. Although in principle amenable to high frequencies and circumferential periodicities, the method has parts of purely numerical nature, which do not allow a too detailed field; for sound propagating into a contraction (the usual case in a turbo engine intake) the prediction of the uniform duct model seems to be always conservative. A spectacular increase of the reflected wave is found for a combination of high Mach number and thin boundary layer in the contraction. ESA

N86-29651*# Purdue Univ., West Lafayette, Ind. School of Aeronautics and Astronautics.
OPTIMAL COOPERATIVE CONTROL SYNTHESIS OF ACTIVE DISPLAYS Final Report
S. GARG and D. K. SCHMIDT 22 Oct. 1985 160 p
(Contract NAG2-228)
(NASA-177102; NAS 1.177102) Avail: NTIS HC A08/MF A01 CSCL 20F

A technique is developed that is intended to provide a systematic approach to synthesizing display augmentation for optimal manual control in complex, closed-loop tasks. A cooperative control synthesis technique, previously developed to design pilot-optimal control augmentation for the plant, is extended to incorporate the simultaneous design of performance enhancing displays. The technique utilizes an optimal control model of the man in the loop. It is applied to the design of a quickening control law for a display and a simple K/s(2) plant, and then to an F-15 type aircraft in a multi-channel task. Utilizing the closed loop modeling and analysis procedures, the results from the display

design algorithm are evaluated and an analytical validation is performed. Experimental validation is recommended for future efforts. Author

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SOCIAL SCIENCES

Includes social sciences (general); administration and management; documentation and information science; economics and cost analysis; law and political science; and urban technology and transportation.

A86-42782#
THE T800 TURBINE ENGINE SOLICITATION - A NEW THRUST IN STREAMLINING THE ACQUISITION PROCESS
J. ACURIO and P. E. BROWN (U.S. Army, Aviation Research and Technology Activity, Fort Eustis, VA) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 22nd, Huntsville, AL, June 16-18, 1986. 8 p.
(AIAA PAPER 86-1669)

The request-for-proposal of the T800 engine to be used by the LHX family of military helicopters was structured to reflect interest in a performance-oriented product, stating requirements and defining boundaries without detailing the methods by which results are to be achieved. This resulted in manufacturers' greater flexibility in parametric tradeoff considerations leading to design optimization. Each proposal received gave detailed commitments and guarantees, citing liabilities that would be explicitly for failure to meet contractual requirements. O.C.

A86-42783#
A SUPPORTABILITY STRATEGY FOR 1995
J. T. RADEMACHER and G. C. NICHOLSON (General Electric Co., Cincinnati, OH) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 22nd, Huntsville, AL, June 16-18, 1986. 8 p.
(AIAA PAPER 86-1670)

The use of the Advanced Tactical Fighter in conjunction with the Joint Advanced Fighter Engine to meet such military requirements as supportability, reliability, maintainability and life cycle cost is discussed. Particular attention is given to an approach for handling the evolution in power plant supportability requirements. The GE37 engine which contains fewer engine components, simpler support equipment, a rational engine module design, and integrally bladed disks is presented as a means of demonstrating the success of the logistics support analysis (LSA) process. It is concluded that the proposed weapon system will both lead the way in the LSA process as well as lay the groundwork for the design systems and infrastructure needed to exploit the emerging technologies of computer aided logistics support in the 1990's. K.K.

A86-42827#
PROPULSION EDUCATION AT THE AIR FORCE INSTITUTE OF TECHNOLOGY
M. E. FRANKE, W. C. ELROD, and E. J. JUMPER (USAF, Institute of Technology, Wright-Patterson AFB, OH) AIAA, ASME, SAE, and ASEE, Joint Propulsion Conference, 22nd, Huntsville, AL, June 16-18, 1986. 8 p. refs
(AIAA PAPER 86-1754)

Propulsion education and student educational needs at the Air Force Institute of Technology are described. The aeronautics and astronautics programs of which propulsion is a part are reviewed to illustrate typical student programs with a propulsion specialty. Course content and research requirements are described in detail. Computational and laboratory facilities are discussed relative to their importance to propulsion education. Typical propulsion research areas are identified and publications are referenced. Author

A86-43333#
DEVELOPING A MAINTENANCE CONCEPT FOR FUTURE ELECTRONIC SYSTEMS
R. O. BLEAU (USAF, Electronic Systems Div., Bedford, MA) AIAA and SOLE, Aerospace Maintenance Conference, 2nd, San Antonio, TX, May 21-23, 1986. 6 p.
(AIAA PAPER 86-1145)

A team composed of U.S. Air Force acquisitions logisticians and prime contractor logistics and design engineers has used several analytical approaches to identify improvements in maintenance support, design, and logistics contracting strategies. The combination of design and support concepts thus achieved increased system supportability at reduced life cycle cost, and yielded a more combat-capable system. Major focuses of the analytic method used were life cycle costs, capabilities, and flexibility. O.C.

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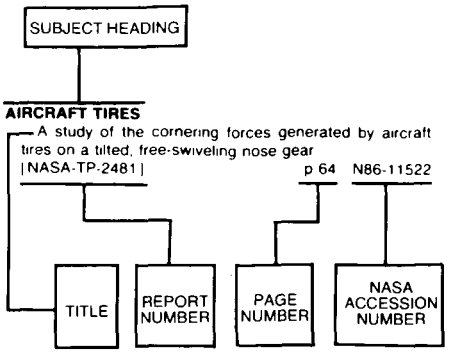

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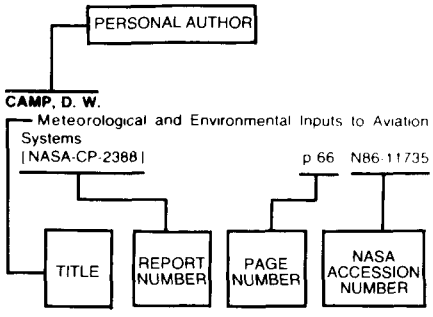

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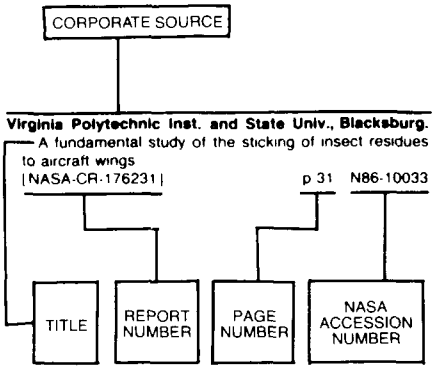

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A

Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).
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[AGARD-AG-280] p 676 N86-29173
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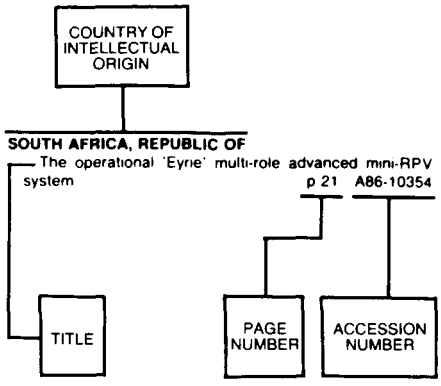

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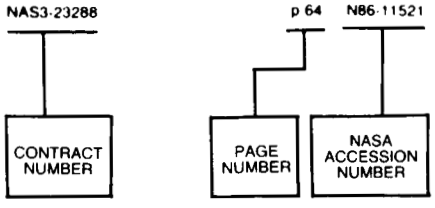

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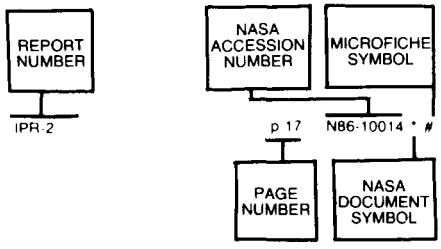

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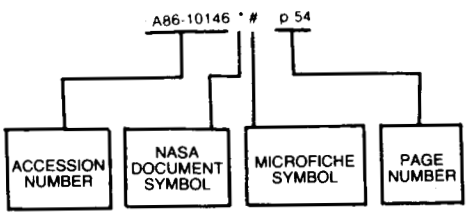

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E14	38.50	77.00
E15	42.00	84.00
E16	46.00	92.00
E17	50.00	100.00
E18	54.00	108.00
E19	60.00	120.00
E20	70.00	140.00
E99	*	*

*Contact NTIS for price quote.

IMPORTANT NOTICE

NTIS Shipping and Handling Charges (effective June 1, 1985)

U.S., Canada, Mexico — ADD $3.00 per TOTAL ORDER

All Other Countries — ADD $4.00 per TOTAL ORDER

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ORDERS REQUESTING NTIS RUSH HANDLING
ORDERS FOR SUBSCRIPTION OR STANDING ORDER PRODUCTS *ONLY*

NOTE: Each additional delivery address on an order requires a separate shipping and handling charge.

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